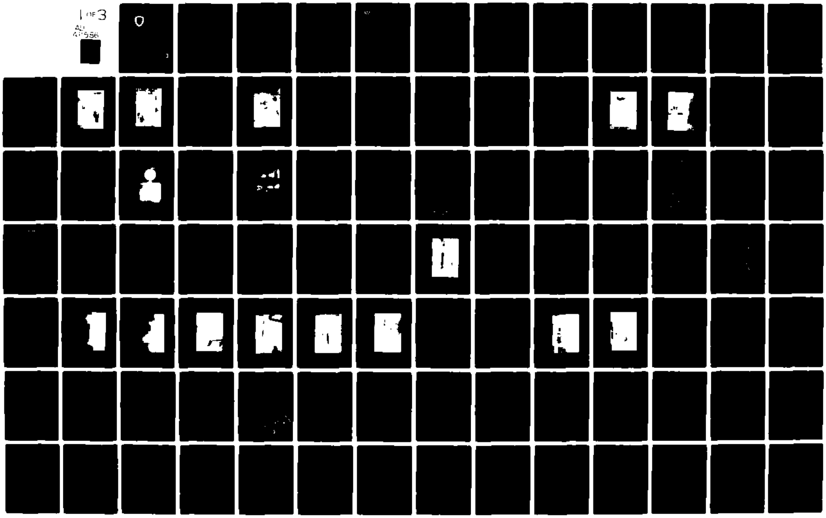
AD-A115 861 ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB CA F/G 1/3
CLIMATIC LABORATORY EVALUATION YCH-47D HELICOPTER.(U)
AUG 81 J R NIEMANN, C F ADAM, J A BROWN
UNCLASSIFIED USAAEFA-79-13 NL

1 OF 3



AD A115861

(12)

USAAEFA PROJECT NO. 79-13

CLIMATIC LABORATORY EVALUATION
YCH-47D HELICOPTER

FINAL REPORT

JOHN R. NIEMANN
PROJECT OFFICER

JERRY A. BROWN
PROJECT ENGINEER

CHARLES F. ADAM
MAJ, FA
US ARMY
PROJECT PILOT

AUGUST 1981

Approved for public release; distribution unlimited.

UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

DISCLAIMER NOTICE

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

TRADE NAMES

The use of trade names in this report does not constitute an official endorsement or approval of the use of the commercial hardware and software.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER USAAEFA NO. 79-13 ✓ AD-	2. GOVT ACCESSION NO. A115861
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) CLIMATIC LABORATORY EVALUATION YCH-47D HELICOPTER	5. TYPE OF REPORT & PERIOD COVERED FINAL REPORT-9Sep-22 Oct 1980
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) JOHN R. NIEMANN CHARLES F. ADAM JERRY A. BROWN	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB, CA 83523	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 19-0-CH022-01-19-EC
11. CONTROLLING OFFICE NAME AND ADDRESS US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND 4300 GOODFELLOW BOULEVARD ST. LOUIS, MO 63120	12. REPORT DATE AUGUST 1981
	13. NUMBER OF PAGES 224
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release? distrubution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Climatic Laboratory Evaluation
Hydraulic Systems
YCH-47D Helicopter
Flight Control Systems

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Engineering Flight Activity conducted a climatic laboratory evaluation of the Boeing Vertol YCH-47D helicopter, from 9 September to 22 October 1980 at the McKinley Climatic Laboratory Armament Division, Eglin Air Force Base, Florida. Approximately 17-1/2 hours of aircraft operating time and 22 test runs were required to complete the test. The YCH-47D systems, subsystems and components were evaluated at stabilized temperatures ranging from -65° F to +125° F. In some cases, inconclusive results were obtained at the colder temperatures because the test was conducted without rotor blades. The foremost of which are the apparent inability of the flight control hydraulic fluid to warm sufficiently for flight and the pilot's inability to neutralize the flight controls prior to engine start. The YCH-47D performed acceptably from -25° F to 125° F and

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

A

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

exhibited potential for operation at a temperature of -50° F. Two deficiencies were identified: (1) failure of the engine control lever to control the engine during start because of excess moisture in the cockpit and (2) the erratic operation of the hydraulic power transfer units at -50°F. A total of 14 shortcomings were also identified. Further engineering testing below -25° F with rotor blades installed is recommended to determine if the hydraulic fluid temperature can be increased and maintained in flight at a level that would provide satisfactory flight control response and to evaluate the use of MIL-H-5606 hydraulic fluid at the lower temperatures. The operator's manual should specify a minimum temperature for aircraft operation.

DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
4300 GOODFELLOW BOULEVARD, ST. LOUIS, MO 63120

DRDAV-D

SUBJECT: Directorate for Development and Qualification Position on the Final Report of USAAEFA Project No. 79-13, Climatic Laboratory Evaluation YCH-47D Helicopter

SEE DISTRIBUTION

1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. The evaluation was conducted using a prototype YCH-47D at the US Air Force Climatic Laboratory, Eglin AFB, FL. The evaluation was conducted with the rotor blades removed to reduce cost. Technically, this approach was considered acceptable since the CH-47C was previously evaluated in the climatic laboratory down to -65°F with only minor problems using MIL-H-5606 hydraulic fluid. It was fully recognized and accepted that the test would not include blade induced steady and unsteady aerodynamic loads. The objectives of this evaluation were to verify that the YCH-47D systems, subsystems, and components could function satisfactory throughout the range of climatic extremes and that there were no undesirable interactions. The Boeing Vertol Company Detail Specification for the Model YCH-47D Helicopter, 145-PJ-7103, requires that individual hydraulic components be designed for satisfactory operation in a local environment of -50°F to +160°F. The intent was to allow operation of the hydraulic system using MIL-H-83282 hydraulic fluid without changing to the MIL-H-5606 hydraulic fluid for temperatures below -25°F as is currently done. Testing was conducted to determine the potential for the YCH-47D to operate to -65°F using the MIL-H-83282, although the Detail Specification requirements are for satisfactory operation to -50°F.

2. This Directorate agrees with the report findings, conclusions, and recommendations with the following exceptions and additional comments provided. Comments are directed to the report paragraphs as indicated.

a. Paragraph 61a. This paragraph implies that the scope of testing was reduced due to testing the YCH-47D without rotor blades installed. Since the climatic laboratory evaluation was planned to be conducted without the rotor blades installed there was no reduction in planned testing. The results of the evaluation are considered just as valid without rotor blades installed as well as if they would have been installed. However, validation of corrections made as the result of this climatic laboratory test should be obtained through cold weather flight testing.

b. Paragraph 61b, 61c, and 61f. The specific conclusions reached in these paragraphs relative to the problem areas of excessive lateral control forces, unsatisfactory flight control system warm up and operation using the APU, hydraulic power transfer units (PTU) slowness in reaching operating temperatures and failure of the aft actuator to respond to control inputs are

all essentially attributable to the high viscous characteristics of the MIL-H-83282 hydraulic fluid at low temperatures.

c. Paragraph 63a. The ECL failure is not considered a deficiency. The failure appears to have occurred because of the test environment which was not representative of the natural environment. The large moisture accumulation resulted from an extreme immediate temperature change. The ECL was qualified to MIL-STD-810, which included the humidity test, however, it appears the moisture exposed to the ECL was excessive as compared to specification qualification requirements.

d. Paragraph 63b. The hydraulic PTU's erratic operation at -50°F is considered a result of the high viscosity of the MIL-H-83282 hydraulic fluid at this temperature (approximately 4,000 centistokes). While not conducted, preheating the PTU's prior to operation could possibly alleviate this erratic operation. The other solution is to change to MIL-H-5606 hydraulic fluid at -25°F to allow satisfactory operation at -50°F. Analysis shows that the viscosity of the MIL-H-5606 at -50°F is approximately 900 centistokes which is slightly greater than the MIL-H-83282 viscosity of approximately 800 centistokes. Based on the preceding, the PTU's should operate satisfactory tc -50°F using the MIL-H-5606 hydraulic fluid. The MIL-H-83282 hydraulic fluid should be changed out at -25°F with the MIL-H-5606 fluid to insure continuous satisfactory operation to -50°F.

e. Paragraph 64a. The excessive control forces below -25°F apparently result from the increased viscosity of the MIL-H-83282 hydraulic fluid. This situation could be aggravated by the hydraulic reservoir/cooler configuration during flight. As ambient and fluid temperatures drop, the hydraulic fluid is not bypassed and is subjected to further cooling as it passes through the cooler. Flight testing to determine if actual flight conditions degrade the already excessive control forces should be conducted in cold climates.

f. Paragraph 64b. The inability of the hydraulic system accumulator assemblies to hold a precharge at temperatures below -25°F was corrected prior to completion of testing. New "O" rings were installed in the Shrader valve and gage and a new "banjo" valve fitting system incorporated which corrected the shortcoming. All pre- and post-run pressures on all test runs following run 12 were within limits.

g. Paragraph 64c. The unsatisfactory operation of the utility hydraulic two-stage handpump at -25°F and below was corrected by opening up system passages to reduce the pressure drops and reconfiguring the inlet valve. As a result of the reconfigurations, the pump efficiency was increased from 90% to 100% at -25°F and from 20% to approximately 60% at -50°F. At -65°F the original configuration efficiency was 0% which was increased to 30% with the reconfiguration.

h. Paragraph 64d. The dual failure of the AFCS at 125°F was an isolated failure that could not be duplicated. Additionally, while the YCH-47D was under-going RAM-D testing at Yuma Proving Ground, AZ, no AFCS failures were experienced at temperatures exceeding 125°F. The actual failure mode is considered to have been the inability of the AFCS pre-engage circuit to null the DASH for normal operative engagement. Since the failed AFCS was an isolated type failure it is not considered a shortcoming.

i. Paragraph 64e. The APU ESU failure at 125°F was an isolated failure which was corrected by replacement of the ESU. Subsequent APU starts with the new ESU were successful. Since ESU failure was an isolated type failure it is not considered a shortcoming.

j. Paragraph 64f. The failure of the No. 2 engine gearbox oil cooler thermal bypass valve in the closed position was evaluated. A failure analysis conducted on the valve showed no reason for the failure and indicated that it was an isolated case. However, two valves were used during the tests and both proved either completely or partially defective.

k. Paragraph 64g. The unreliable transmission oil level indication resulted from reading the oil level before oil drain back and temperature stabilization was complete. The maintenance manual will define modified servicing procedures which will allow checking oil levels after drain back is complete and temperatures have stabilized.

l. Paragraph 64h. The coarse scale and small size of the accumulator indicators are inconsistent with the stated precharge pressure. However, these are the standard indicators which are still satisfactory for use. Consequently, there are no plans to redesign.

m. Paragraph 64k. The apparent short life of the forward transmission input seal will be corrected. The seals for the production CH-47D will be changed to a different material based on seals qualified during the transmission qualification and RAM tests conducted by the Boeing Vertol Company.

n. Paragraph 64l. Failure of the crew chief microphone cord protective covering at -25°F and below was corrected. The cord protective covering material is changed to a material meeting -65°F requirements.

o. Paragraph 64m. The inability of the battery to provide adequate power to initiate an APU start at -25°F has been a problem on the CH-47 model helicopter for several years. Currently, the battery allows an APU start at approximately -15°F to -20°F. Below these temperatures, maintenance procedures require preheating the battery, which has been standard field procedure.

p. Paragraph 64n. The hydraulic system servicing required following a temperature change is associated with the shortcoming reported in paragraph 64b

of the report. This shortcoming was corrected and hydraulic system servicing should no longer be required following a temperature change.

q. Paragraphs 65a and 65b. The problems associated with operating the YCH-47D at -65°F result from using the MIL-H-83282 hydraulic fluid. The fluid becomes so viscous that the PTU's could not pressurize the flight boost system or operate the power steering system. It is emphasized that although specification requirements do not require operation below -50°F, the YCH-47D was tested at a lower temperature to evaluate the potential of the helicopter hydraulic system to operate at these extreme temperatures with the MIL-H-83282 hydraulic fluid.

3. Based on the preceding, the YCH-47D hydraulic components demonstrated acceptable operation with the MIL-H-83282 hydraulic fluid to -25°F only. Operation at -50°F was unacceptable. The exact temperature at which the helicopter operation becomes unacceptable is undetermined, however the lowest temperature tested at which operation was acceptable was -25°F. As discussed under paragraph 2d above, the viscosity of the MIL-H-83282 hydraulic fluid at -25°F is approximately equal to MIL-H-5606 hydraulic fluid at -50°F (approximately 800 centistokes versus 900 centistokes respectively). Consequently, a solution to the preceding would be to use MIL-H-5606 hydraulic fluid below -25°F. The capability of the YCH-47D to operate satisfactorily to -50°F using the MIL-H-83282 hydraulic fluid fails to meet the requirements of paragraph 3.2.8 and 3.18.1 of the detail specification. Based on the preceding, it recommended that the CH-47D be subjected to cold weather flight testing to evaluate incorporated fixes, use of MIL-H-83282 hydraulic fluid with special emphasis on flight control characteristic changes with temperatures, and operation of the PTU's with the use of MIL-H-5606 hydraulic fluid as an alternative to MIL-H-83282 hydraulic fluids at the low temperatures.

FOR THE COMMANDER:

CHARLES C. CRAWFORD, JR.
Director of Development
and Qualification

TABLE OF CONTENTS

APPENDIXES

DISTRIBUTION

INTRODUCTION

BACKGROUND

1. The United States Army Aviation Research and Development Command (AVRADCOM) contracted with the Boeing Vertol Company (BV) to design, fabricate, test and qualify the YCH-47D helicopter. AVRADCOM tasked the United States Army Aviation Engineering Flight Activity (USAAEFA) to conduct and report on a Climatic Laboratory Evaluation of the YCH-47D (ref 1, app A) prior to qualification and release of the helicopter for arctic tests. Since the YCH-47D is a derivative of the CH-47C which was previously tested by BV a complete survey was not deemed necessary by AVRADCOM. USAAEFA was tasked to conduct the YCH-47D Climatic Laboratory Survey with rotor blades removed. The helicopter was tested in the Engine Test Cell facility of the US Air Force Climatic Laboratory at the Armament Division (AD) Eglin Air Force Base, Florida, in accordance with the USAAEFA Test Plan (ref 2, app A).

TEST OBJECTIVES

2. The objectives of the Climatic Laboratory tests were to evaluate to the extent possible without rotor blades the operation of the YCH-47D systems, subsystems, and components throughout the temperature range of -65° F to 125° F. An additional objective of the test was for the US Army Aviation Development Test Activity (AVNDTA) Fort Rucker, Alabama to evaluate the reliability, availability and maintainability (RAM) of the aircraft.

DESCRIPTION

3. The YCH-47D is a modernized version of the CH-47 helicopter airframe. It is a tandem rotor, twin-engine, turbine-powered cargo helicopter manufactured by BV. A more detailed description of the test vehicle is contained in the operator's manual (ref 3, app A) and in appendix B.

4. Modifications to the aircraft for the Climatic Tests included removal of the rotor blades, the installation of a data system (app C), three support jacks, tie down cables, and exhaust ducting associated with the engine test facility installation.

TEST SCOPE

5. Environmental testing of the YCH-47D helicopter was conducted in the McKinley Climatic Laboratory at Eglin Air Force Base, Florida. Approximately 17-1/2 hours of aircraft operating time were required to complete the test. A total of 22 test runs were conducted during the period of 9 September to 22 October 1980. Test instrumentation was installed and maintained by BV personnel. AVNDTA maintained the aircraft and provided all logistic support. RAM data recorded and evaluated by AVNDTA will be presented in a separate report. The 3246th Test Wing at AD operated the test chamber in accordance with the test plan and provided tie-downs and exhaust ducts for the aircraft. The Freeman Mathematics Laboratory (FML) of AD provided data processing support. The aircraft was operated in accordance with the operators manual (ref 3, app A) and the special operating instruction received from AVRADCOM (ref 4, app A). The tests were conducted at the following sequence of temperatures; 70° F, 0° F, -25° F, -50° F, -65° F, 70° F and 125° F.

TEST METHODOLOGY

6. The applicable test procedures and recommended instrumentation requirements contained in military specification MIL-E-5272C and MIL-I-5289B (refs 5 and 6, app A), Army Materiel Command Pamphlet 706-203 (ref 7, app A) and the USAAEFA instrumentation specification for Climatic Laboratory Tests (ref 8, app A) were utilized as a guide for this test.

7. The YCH-47D was exposed to a stabilized temperature environment for a period in excess of 48 hours following a temperature change to assure equilibrium throughout the airframe and engines, and for approximately 24 hours between runs at the same temperature. The aircraft was inspected prior to each run utilizing a 10 hour inspection guide which is more extensive than a normal turnaround inspection and provided a thorough check of all components. MIL-L-23699 oil was used in the transmissions, engines and the auxiliary power unit (APU) at -25° F and above and MIL-L-7808 was utilized below -25° F. JP-5 fuel was used at -25° F and above while JP-4 was used below -25° F. MIL-H-83282A fire resistant hydraulic fluid was used at all test temperatures. The aircraft fuel temperature was utilized as an indication of adequate cold soak time. Data were obtained by recording all parameters on magnetic tape, from manual records and hard copies of a cathode ray tube (CRT) monitor in the data room. A standard procedure (app D) developed for this test was utilized to sequence and correlate all actions during the test. Each test included a preflight and postflight inspection in accordance with the test plan. A record of these inspections was maintained and information from them is included in this report. The data generated at the 70° F temperature was used as a base line for comparison with data obtained at other temperatures. The duration of each run was dependent on the time required for the aircraft systems fluid temperature to stabilize and was generally less than one hour.

8. The aircraft was positioned in the engine test facility (photos 1 and 2), supported by jacks at three points and secured to floor anchor points and by weights provided by the Climatic Laboratory. The aircraft was jacked to a 2 degree nose up/ground attitude with partial weight remaining on the forward wheels. As a consequence of operating the aircraft without rotor blades, the engines, transmission, drive shafts, dampers, controls and hydraulic actuators were not subjected to blade induced dynamic and aerodynamic loads.

9. Not all data obtained during the test are presented in this report, and generally, only one representative run profile per temperature is shown. The additional data will be on file at USAAEFA for two years following publication of this report.

RESULTS AND DISCUSSION

GENERAL

10. The YCH-47D was tested at temperatures of -65° F to +125° F in accordance with the test request (ref 1, app A). The Prime Item Development Specification (PIDS) (ref 9, app A) states in paragraph 3.18.1.1.1 that "Both flight control hydraulic systems shall be Type II, 3000 psi class except that the temperature range shall be -50° F to +275° F in lieu of -65° F to +275° F..." and in paragraph 3.2.8 "Individual components, however, shall be designed for satisfactory operation in a local environment of -65° F to +160° F except that individual hydraulic components shall be designed for satisfactory operation in a local environment of -50° F to +160° F." In general, the YCH-47D aircraft performed acceptably from -25° F to 125° F and exhibited potential for operation at temperatures of -50° F. The APU was successfully started with a cold battery at temperatures of 0°F. At -25° and -50°F the APU generally started on the second start attempt. Heat was required at -65° F to start the APU. The engines started satisfactorily at all temperatures. The hydraulic system was marginally acceptable at -50° F and below. Control forces were high at cold temperatures and the flight control system, utilizing APU utility hydraulic power, was difficult to operate at temperatures below -25° F. The pilot was able to neutralize the flight controls and start the engines at -50° F however, power transfer unit (PTU) operation was totally unsatisfactory at -65° F and would not allow any control movement prior to engine start. The engines could be started at -65° F without neutralizing the flight controls only because this aircraft had the rotor blades removed. In some cases, inconclusive results were obtained at the colder temperatures because the test was conducted without rotor blades, which may affect the applicability of these data to operational units.

11. Two deficiencies were identified in this program. They are the failure of the engine control lever (ECL). to control the engine during start because of excessive moisture in the cockpit and the hydraulic power transfer units operated erratically at -50° F. A total of 14 shortcomings were identified including excessive lateral control forces at -25° F and below, failure of the accumulator assemblies to hold a precharge below -25° F, and unsatisfactory operation of the utility hydraulic two-stage hand pump at -25° F and below.

12. Sample data are presented in appendix E for each ambient test temperature. The electrical survey is presented at -65°, 70°, and 125° F and an engine shutdown with immediate restart is presented at 125° F. Frequency response data of the flight control system, including the integrated lower control actuator (ILCA), and the forward and aft upper boost control swiveling actuators are also presented in appendix E.

AUXILIARY POWER UNIT

General

13. The YCH-47D is equipped with a Solar model T-62-T-2B gas turbine APU. The unit is located in the aft pylon and exhaust gases exit via a stainless steel duct through the trailing edge of the pylon. The APU was started prior to engine start to provide electrical power and hydraulic pressure for flight controls operation and check, and supplying hydraulic pressure for the engine starter motor. The APU is normally shut down after engine start and restarted prior to engine shutdown. The

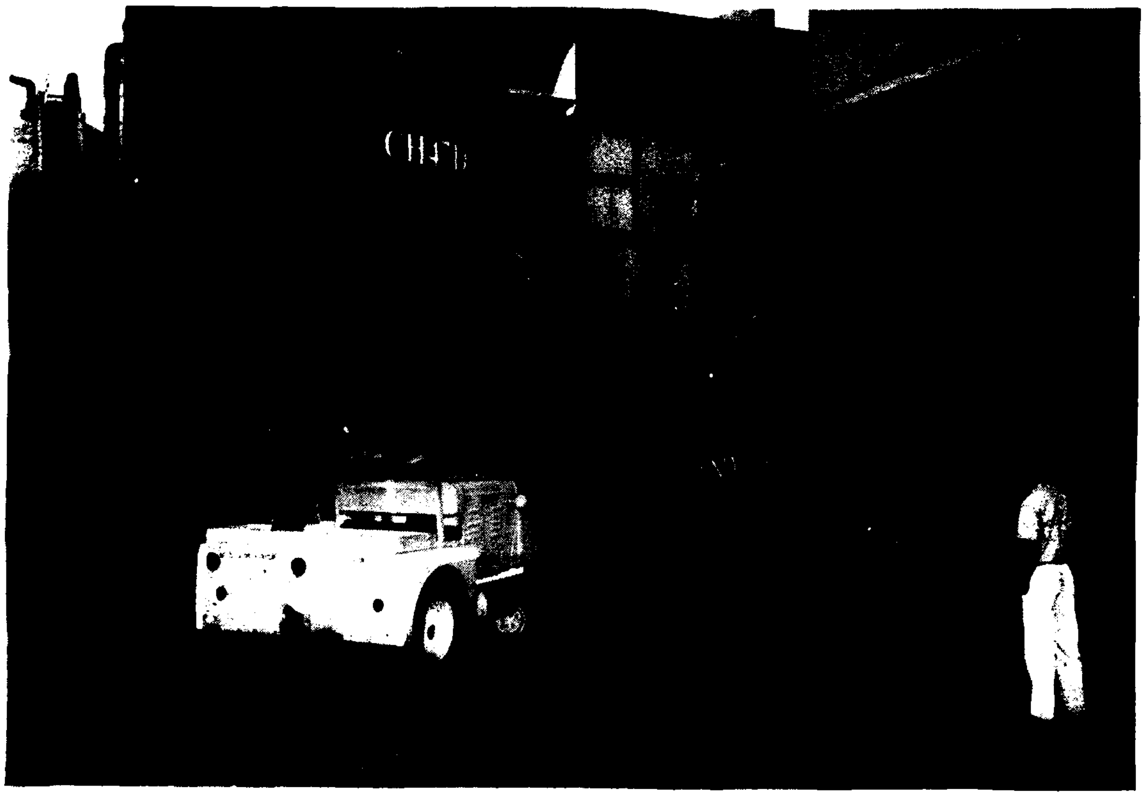


Photo 1. YCH-47D Entering Test Cell

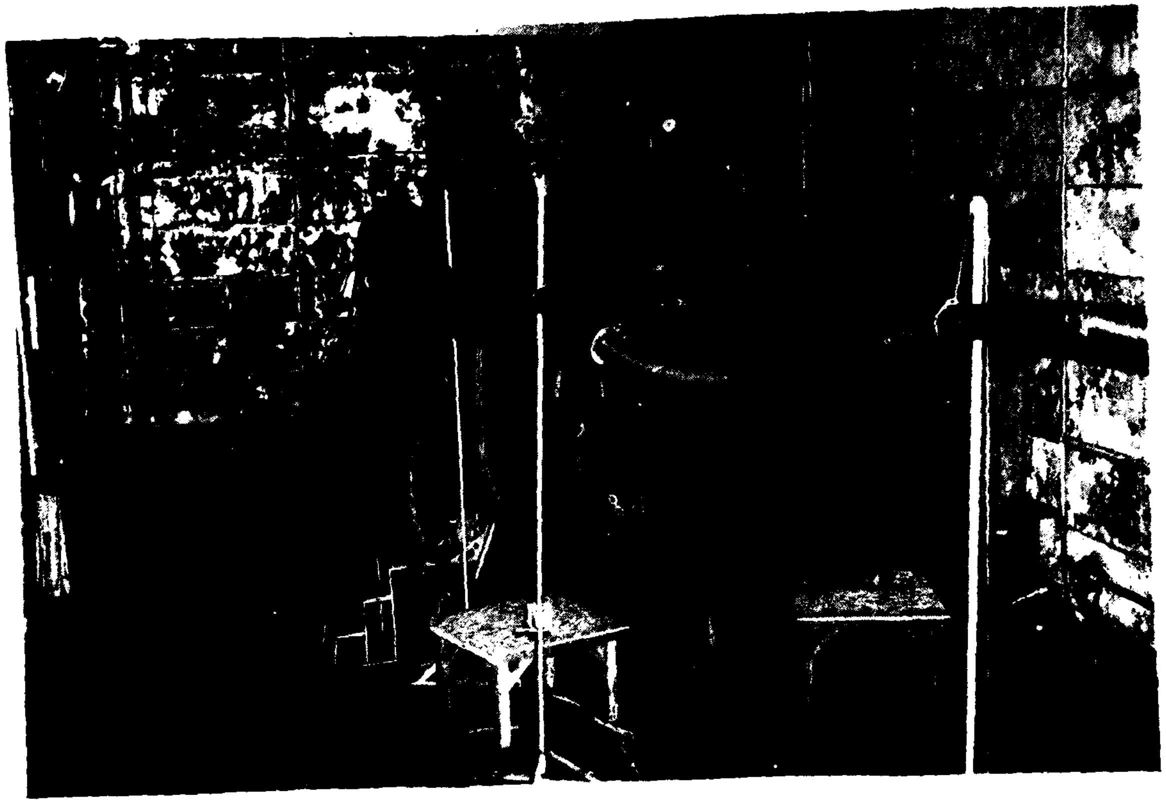


Photo 2. YCH-47D In Test Cell - Right Side

APU was serviced with MIL-L-23699 oil for ambient temperatures of -25° F and above, and MIL-L-7808 below -25° F. JP-5 fuel was used at -25° F and above and JP-4 fuel was utilized below -25° F.

Starting

14. Time histories of APU starts are included in figures 1 through 12, appendix E. APU start attempts are presented at -25° F and -65° F. APU starts were not achieved on the first attempt below 0° F. There was one exception where the APU started on the first attempt at -50° F and that start is presented in figure 5, appendix E. There were seven APU starts on the second attempt and one on the third attempt at temperatures of -25° F and -50° F. In most cases, sufficient rpm (self-sustaining) was not reached and the start self-aborted. On several attempts exhaust gas temperature (EGT) exceeded 685° C and the electronic control unit (ECU) aborted the start. At -65° F preheating of the APU, start accumulator, and signal accumulator for 10 minutes was necessary to achieve a satisfactory start. A Herman Nelson heater with a three-way splitter on the output duct was used to provide the heat. Maximum APU oil pressures were attained at the colder ambient temperatures and reached approximately 145 psi. Following start and warm-up APU oil pressures stabilized between 35 and 48 psi (normal range).

15. An external power cart located outside the test chamber was used to furnish electrical power prior to APU start and to charge the battery during the work day. This electrical connection is visible in photo 3. At temperatures below 0° F, a cold-soaked aircraft battery was found to be incapable of providing adequate electrical energy to open the APU pilot valve solenoid in the APU start module. At temperatures below 0° F, the battery was removed from the aircraft for overnight storage at room temperature (para 36).

16. The utility hydraulic two-stage hand pump assembly was unsatisfactory at temperatures of -25° F and below. When the APU failed to start, the hand pump was used to pressurize the APU start accumulator. The hand pump was utilized to the point where the by-pass limited any additional pressure. The variety of values at which the by-pass functioned are reflected in the APU start pressure data in appendix E. In excess of 1000 cycles of the hand pump were required to recharge the APU start accumulator from zero to the 3000 psi specified in DEPTM 55-1520-240-10. The hydraulic fluid lines at the base of the pump required preheating with a hand held heat gun to permit the fluid to flow into the pump and eliminate partially effective strokes. With preheating, greater that 400 cycles were required to achieve 3000 psi in the accumulator. A more detailed discussion is contained in paragraph 48.

17. The APU start and signal accumulators would not hold a precharge below -25° F. The start accumulator failed to accept or hold a charge on one occasion at -65° F and was removed from the aircraft. Upon reaching 70° F the APU start accumulator functioned normally and was reinstalled and used for the remainder of the testing including additional runs at -65° F. The hydraulic section (para 46) has a more detailed discussion of the failure of the accumulators to hold a precharge.

18. In summary, APU starts were successfully accomplished at temperatures of 0° F and above and generally on the second attempt at -25° and -50° F. Heat was required on the APU, oil reservoir, and the APU start and signal accumulators at -65° F to achieve a start. The APU starting characteristics should be improved for

Photo 3. YCH-47D In Test Cell - Left Side

reliable operation below 0° F. The areas of concern are the operation of the two stage utility hydraulic hand pump, the APU start accumulator and the signal accumulator (para 46 and 48).

Performance and Operation

19. Following a start the APU performed satisfactory. The APU rpm stabilized at approximately 101 ±1/2 percent on all tests and the EGT varied from a stable 400° C at a test temperature of 125° F to a low of approximately 225° C at -65° F Operation of the APU at 125° F was satisfactory. However, the APU failed to restart on one occasion at 125° F due to an ECU failure. Temperatures in the vicinity of the ECU were in excess of 170° F during the engine run. A spare ECU was installed and operated satisfactorily on the following run at 125° F. Failure of the ECU at 125° F ambient temperature is a shortcoming. Data for APU warm-up/run are presented in figures13 through 19, appendix E.

Shutdown

20. The APU was shut down following engine start and restarted prior to engine shutdown. All APU shutdowns and restarts were normal with the exception of the ECU failure (para 19).

ENGINES

General

21. The YCH-47D is powered by two Lycoming Model T55-L-712 turbine engines. The engine power ratings may be found in appendix B and the operator's manual, (ref 3, app A). The engines were serviced with MIL-L-23699 oil at temperatures of -25° F and above and with MIL-L-7808 oil below -25° F. Fuel used during this test was JP-5 at -25° F and above and JP-4 below that temperature. Engine oil samples were tested throughout the program and the results were normal.

22. The engines were successfully started at all temperatures and experienced no major problems during this test program. Standard operating procedures identified in the operator's manual (ref 3, app A) were utilized for all engine operation. The test profile consisted of engine start, operation at GROUND and FLIGHT, and engine shutdown. While at FLIGHT the rotor speed was beeped to 225 rpm; however, there was no indication of engine torque because the test was conducted without rotor blades. The run time was generally the time required for temperatures and pressures to stabilize. The engine data are presented in figures 20 through 44, appendix E.

Starting

23. The T55-L-712 engines installed in the YCH-47D started satisfactorily at temperatures of -65° F to +125° F including satisfactory shutdown with immediate restart at -50° F and +125° F (fig. 26, app E). Engine starting data are presented in figures 20 through 32, appendix E. The engines were started on all runs with the exception of run 10 where they were intentionally motored to 10 percent N_1 rpm only. Run 10 was the first test at -50° F and the engines were motored only to check hydraulic line integrity and start motor operation at a cold temperature. Hydraulic

seep (fluid) was noted around the start motor after this run. The associated bolts and fittings were retorqued and no further evidence of leakage was found. The first engine was started using a start motor powered by APU utility hydraulic pressure. To further investigate the high torque loads experienced by the engine start motor, especially at the colder temperatures, the start sequence was alternated between the engines from run to run. Engine acceleration, time *i.e.*, time to 10 percent N_1, and idle, (60-63 percent N_1,) etc., were longer at the colder temperatures. The average time to 10 percent N_1 at an ambient temperature of -65° F was approximately 50 seconds compared to 6 seconds at an ambient temperature of 70° F. Maximum engine oil pressure during start averaged approximately 85 psi at 70° F and ranged from 115 to 135 psi at -58° F test cell temperature. Maximum power turbine inlet temperature (PTIT) varied during start from approximately 500° C at -65° F to 600° C at 125° F.

24. The No. 1 ECL failed to control the engine during a start at 70° F. The temperature in the chamber had been raised to 70° F from -65° F and a large amount of moisture had condensed on the inside of the aircraft. The ECL failure was detected during the start sequence when accelerating the engines from GROUND to FLIGHT. The ECL would not control the actuator which rapidly extended to full travel requiring use of the DC emergency beep to prevent an overspeed condition. The ECL operated normally when the chamber was dry. The moisture accumulated in the cockpit was similar to conditions experienced in S.E. Asia. The inability of the ECL to control engine acceleration during start due to moisture in the ECL box is a deficiency.

Performance and Operation

25. Engine operation on this test consisted of the following: acceleration from GROUND (60 to 63 percent N_1) to FLIGHT at minimum beep (approximately 70 percent N_1); and engine operation at 225 rotor rpm. With the ECL's at FLIGHT engine torque meter indications were below the scale and to achieve equal engine loading, the gas producers were matched to produce 225 rotor rpm. The engines were checked for anti-ice operation, see test procedure in appendix D, by noting a (PTIT) increase after actuating the engine anti ice switch. Engine run characteristics are presented in figures 33 through 44, appendix E. Engine operating times varied from 15 to 45 minutes, depending on the ambient temperatures. The PTIT on both engines stabilized at approximately 350° C at an ambient temperature of -65° F to 575° C at 125° F. Engine oil pressures ranged from approximately 30 psi at 125° F and 55/65 psi at -65° F. The engines operation was satisfactory at all test temperatures.

Shutdown

26. At engine shutdown, the ECLs were placed in the GROUND position and the engines stabilized for one minute. The engines were shutdown in the same sequence that they were started. All engine shutdowns were normal with no unusual occurrence except run 5, when the shear sections of both main generators failed. During this shutdown sequence the No. 2 engine ECL was placed in the STOP position followed approximately 10 seconds later with the No. 1 engine ECL to STOP. A loud metallic sound was heard immediately following the No. 1 ECL movement to STOP. A post run inspection did not reveal the cause of the sound but on start up for the next run both aircraft main generators were inoperative. Removal and inspection of the generators indicated both shear sections had failed. The

generators were replaced and the failed units were shipped to BV for analysis. During the shutdown from run 5 the data indicated a rotor rpm decrease with the No. 2 N_2 rpm the first engine cut, until the No. 1 engine ECL was moved to stop. It is believed that sprag clutch slippage prevented mechanical release of the drive train from the No. 2 engine while slowing down. As the rotor hub was slowing to a stop the No. 1 clutch engaged the No. 1 engine at a much higher N_2 rotational speed. This abrupt change could create a load on the drive train of such a magnitude as to fail the generator shear sections. The deceleration characteristics of the rotor without blades differ from that with blades. The lack of momentum provided by the mass of the blades contributed to the sprag clutch malfunction and may have caused the failure. The relationship of the engine N_2 speed rotor speed was monitored carefully during the rest of the program to prevent a reoccurrence of this failure. At -50° F and 125° F the No. 1 engine was shut down and immediately restarted with no unusual occurrence. Data are presented in figure 26, appendix E of the No. 1 engine shutdown/restart at 125° F.

AIRFRAME

General

27. The BV YCH-47D is a modernized version of the CH-47 aircraft. Component refinements incorporated include new rotor blades, upgraded transmissions and external cargo suspension equipment and improved hydraulic, electrical and flight control systems. An aircraft description is contained in reference 3, appendix A, and appendix B. The Prime Item Development Specification (ref 9, app A), defines the configuration of the CH-47D model aircraft.

Avionics

28. All aircraft communications, navigation, and intercom equipment were powered and manually checked for satisfactory operation during each run. No avionics equipment failure was noted during this evaluation throughout the temperature range of -65° to 125° F. During the 125° F ambient temperature test, temperature sensitive tape was located in the center console at four positions. The temperature sensitive tape indicated temperatures in excess of 130° F but less than 150° F in the center console. During the tests at 125° F temperatures of approximately 158° F were detected in the avionics compartment. Both the No. 1 and No. 2 advanced flight control systems (AFCS), which are located in the avionics Compartment, failed at this temperature (para 40).

Cabin Temperature Survey

29. Heating system operation was monitored at all test temperatures with the exception of 125° F. Instrumentation sensors were installed in the cockpit, cabin and the heater duct. For all test temperatures the cabin air and cockpit air switches were ON and defrosters were OFF. At 70° F one run was accomplished with cabin air ON only. The data are presented in figures 45 through 50, appendix E and summarized in table 1.

30. The heater output temperature at an ambient temperature of -25° F was approximately 80° C (176° F). The temperature differential between ambient and heater output was approximately 100° C (212° F) at -25° F. The heater output

Table 1

Summary - Cabin Temperature Survey

AIM Test Temp °F	ACTUAL Test Cell Temp °C	Heater Temp Output	STABILIZED TEMPERATURES °C Sta 320 Temp	Head Level	Pilot's Temp Waist Level	Foot Level
70[2]	20	—[1]	39	63	60	70
70[3]	21	—[1]	38	29	32	31
0	-18	—[1]	4	15	25	30
-25	-30	76 to 67	-3	0	14	20
-25	-31	75	-9	5	12	17
-50	-44	30	-22	-17	-9	-6
-50	-44	36	-20	-15	-6	0
-65	-54 to -47	30	-25	-20	-10	-4
-65	-53 to -48	29	-27	-25	-15	-5

1 Data not available, limited by instrumentation.
2 All heater output to cabin and cockpit.
3 All heater output to cabin only.

temperature below -25° F ambient was approximately 30° C (86° F) which was a differential of approximately 80° C (176° F) over ambient test cell temperature. The aircraft heater was used at 70° F temperature for test purposes only. One test, figure 46 (app E), all heater output air was ducted to the cabin while on a second test, figure 45 (app E), air was ducted to both cabin and cockpit areas. It was noted that the cabin temperature remained the same on both runs while the cockpit reached temperatures in excess of 40° C (104° F) with the cockpit air switch in the ON position.

31. Paragraph 3.23.1 of the Prime Item Development Specification for the CH-47 (ref 9, app A) states "The capacity of the heating system shall be sufficient to maintain the crew and passenger compartment at a temperature of 40° F (4.4° C) with an outside air temperature of -25° F to a maximum altitude of 10,000 feet." The cabin temperature at station 320 was approximately 40° F at an ambient test temperature of 0° F but failed to meet the requirement of reference 9 at an ambient temperature of -25° F. The cockpit temperature at the pilot's head level also did not achieve 40° F at a test temperature of -25° F. The cabin temperature does not meet the specification requirement of 40° F at an ambient temperature of -25° F. The cabin and cockpit temperatures at test ambient temperatures of -50° and -65° F (figs. 49 and 50, app E) ranged from -10° C (14° F) to -30° C (-22° F). The cabin and cockpit temperatures at -25° F and below are uncomfortable, fatiguing to the crew and a shortcoming.

Cargo Handling Equipment

32. The cargo handling equipment, consisting of the winch/hoist and the triple hook system generally operated satisfactorily. The winch/hoist system was functionally checked at each test temperature. The winch was operated and the operation monitored by the crew chief. It was then connected to a load of approximately 600 pounds (photo 4), which was raised and lowered at the direction of the crew chief. The triple cargo hook system was qualitatively evaluated at each test temperature. The hooks were tested with a static load of approximately 15 pounds (photo 5), and armed and released by the normal mode from the cockpit. The normal release is accomplished by an electrical release signal for the forward and aft hooks and an electrical/hydraulic signal for the center hook. The manual release of all three hooks was checked by the crew chief. The center cargo hook accumulator which is normally serviced to 2100 psi did not hold pressure at -65° F ambient temperature. It was serviced and functioned normally at 70° F. The normal release of the center hook was not affected by the failure of the accumulator to hold pressure. The only effect was that the center hook would not return to normal position after a release. Throughout the testing the cargo hooks operated satisfactorily in the "normal release" mode.

Electrical Systems

33. Primary electrical energy for the aircraft is provided by a three-phase, 115/200 volt, 400 Hz AC system. Two AC generators, driven by the accessory gearbox and rated at 40 KVA each furnish power while in flight, and a 20 KVA APU-driven generator provides power for ground checkout and engine starting functions. A 24 volt ni-cad battery provides electrical power for the APU start. A ground power unit was used prior to test runs for instrumentation prerun tests and calibrations and after each run to charge the aircraft battery. The battery was charged until full charge indication was achieved.

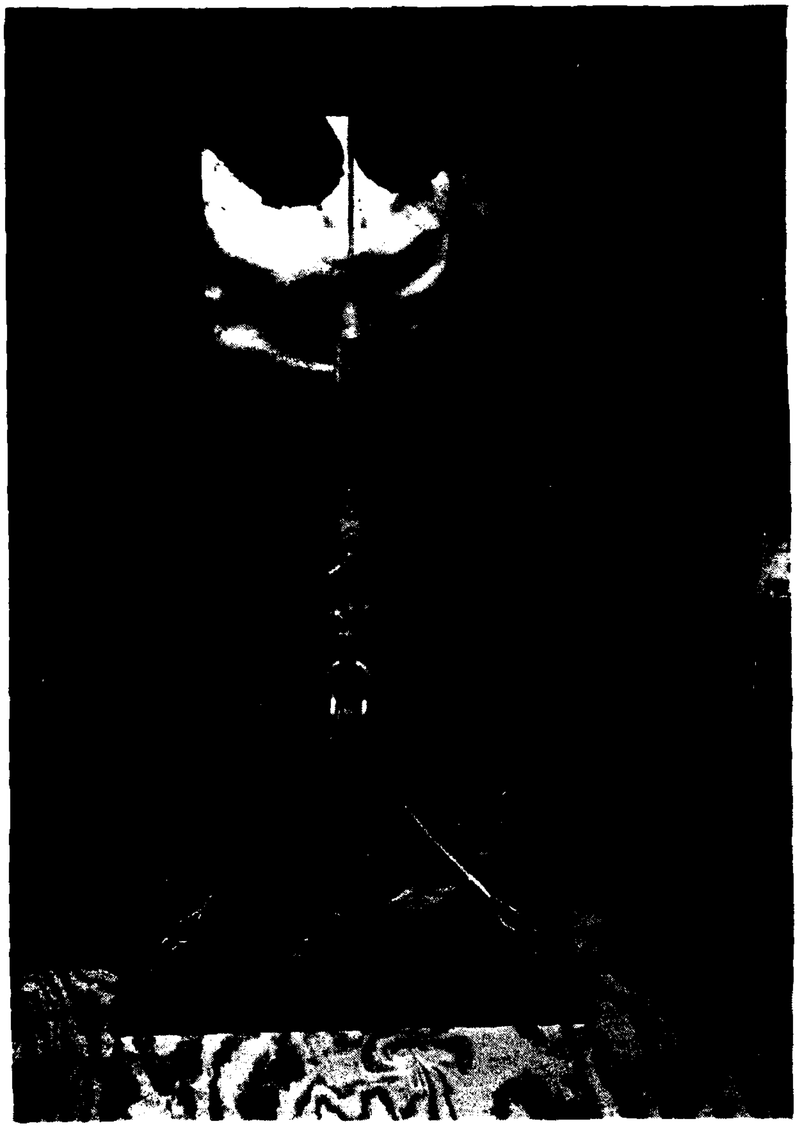


Photo 4. Hoist Operating Load

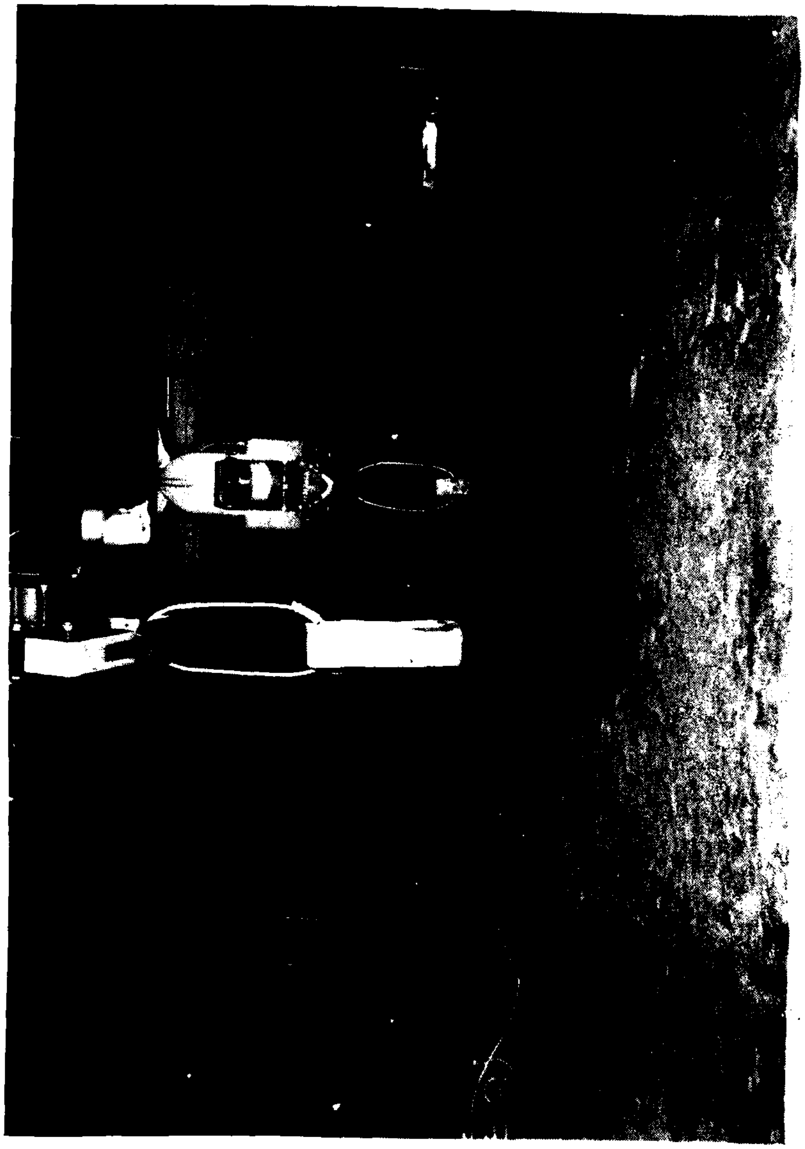


Photo 5. Hook Loads

34. During the engine warmup and temperature stabilization period a failure of the number one generator was simulated to assess its effect on the electrical system at various temperatures. Two BV supplied electrical load banks were utilized to create an electrical system load. The load was gradually increased to approximately 30 KVA, 15 for each load bank and the number one generator switched to the off position. The electrical instrumentation parameters were unreliable through run 17, however, typical system response is presented in figures 51 through 53, appendix E. The electrical system automatically switched the entire load to the number two generator with little or no noticeable affect on frequency or voltage. Both AC generators failed during shutdown at the end of run 5. As a result of an apparent abrupt torsional load placed upon the transmission, the drive shaft shear section of each AC generator were sheared. The events leading to this malfunction are discussed in paragraph 26.

35. Operation of the 20 KVA APU driven generator was monitored throughout the test and it functioned without problems.

36. The aircraft battery performed satisfactorily at temperatures of 0° F and above. At temperatures below 0° F, however, the battery was unable to maintain operating voltage or accept a charge without preheating. At temperatures below 0° F a cold-soaked battery was unable to provide adequate power to open the APU pilot valve solenoid in the APU start module and is a shortcoming. At all tests below 0° F the aircraft battery was removed and stored outside the test chamber at room temperature as recommended in the operator's manual (ref 3, app A). The battery was reinstalled immediately prior to each test.

Flight Controls

37. The flight control system was qualitatively evaluated at each test temperature. Prior to engine start the controls were exercised to determine functional operation, *i.e.*, full throws, forces and response. The flight control systems were powered by pressure from the APU utility hydraulic pump via the PTU's to the flight control actuators. The PTU operation and ability to power the flight control systems was evaluated prior to engine start and after engine shutdown. Following engine start the controls were again cycled to qualitatively determine the effort and time required to achieve aircraft flight capability. Flight control frequency response was evaluated through the use of a signal generator input to the pitch ILCA and monitoring the output of the ILCA, and forward and aft swiveling actuators. The AFCS operation was evaluated by nulling longitudinal stick position versus differential airspeed hold (DASH) errors.

38. A qualitative evaluation of the flight control forces was made by the crew following identical procedures during each test. The test technique is detailed in appendix D and hydraulic system data are presented in figures 101 through 108. At ambient temperatures of -25° F and below the cotrols were stiff and forces comparatively high at the start of the flight control system testing. To displace the control at -50° F and below a high constant force was required by both pilots. The rate limiting characteristics of the flight controls were evaluated 13 minutes after PTU activation at a test temperature of -50° F (fig. 104). A constant 4 pound force, 2 pounds greater than the force gradient was applied to the longitudinal cyclic 1 inch forward of center and a displacement rate of 10 inches per minute recorded. At 5.5 inches forward of center a 10 pound force, 2 pounds greater than the force gradient, produced a displacement rate of 2.6 inches per minute. The No. 1

hydraulic reservoir/cooler *input temperature* was -42° C. These displacement rates were taken from test data at -50° F (specification point) and are considered unacceptable for flight. To improve the system response the controls were exercised as vigorously as possible throughout their full travel. The hydraulic fluid was slow to warm and required two or more minutes of control movement to attain the maximum temperature at the return line to the No. 1 hydrauiic reservoir/cooler. At -56° F test temperatures the control displacement possible was limited to centering the controls (par. 39). After the engines were started the transmission hydraulic pumps provided approximately 3000 psi pressure to the system. Both pilots exerted consideral force on the controls to get any displacement. The controls were exercised for 5 minutes before full displacement could be achieved. The maximum fluid temperature at the input to the No. 1 hydraulic reservoir/cooler was -18° C (fig. 106). At that time the longitudinal cyclic could be displaced throughout its full travel with a constant force of approximately 10 pounds. It must be noted that the refrigeration system in the hanger was unable to maintain the test cell temperature at -65° F and the cell warmed to approximately -58° F towards the end of the run. The lateral cyclic required considerably more force and exhibited slower attainable rates than the longitudinal cyclic at temperatures of -25° F and below. An attempt to isolate the source of the increased lateral force was made by removing the lateral viscous damper from the system. The lateral forces, with the damper removed, compared qualitatively with the longitudinal forces. The lateral cyclic with the damper installed was the controlling factor in evaluating control forces. Control force instrumentation parameters were not calibrated to the grip or pedals and produced unusable data. The system characteristics were measured with a handheld force gage and cockpit instruments at 70° F and pilot qualitative evaluation made at the other test temperatures. At temperatures of -25° F and below the flight controls were not considered, qualitatively, flight responsive until the temperature of the fluid returning to the cooler was greater that -17° C and then only marginally acceptable. The *hydraulic fluid temperature* dropped when the controls remained stationary (figs. 104 through 106, app E). It was not determined if the rotor blades removed aggravated (*i.e.*, rotor wash might further cool the fluid) or improved (rotor control loads might increase the fluid temperature) the situation (par. 10). The excessive lateral control forces at -25° F and below may affect flight operations and safety. The excessive control forces below -25° F is a shortcoming. Further testing with the blades installed should be conducted to determine if the aircraft is operationally able to fly at temperatures below -25° F.

39. The PTU's were slow to reach operating pressure at temperatures of -25° F and below and were completely unsatisfactory at -65° F. At ambient temperatures of -50° F, the PTU's were activated after the APU start and required from 1 to 7 minutes to reach 3000 psi (fig. 104 and 105, app E). A small control displacement at a slow rate caused the pressure to drop below 1950 psi (fig. 105, app E). The No. 1 hydraulic caution light would illuminate and the pressure operated valve would depressurize the system. The pressure would then increase above 2300 psi and return the system to normal operation. The same pressure characteristics were noted on the No. 2 system and would alternate between boost systems. The independent boost system checks were unsatisfactory in that a single PTU would not maintain pressure throughout the control sweep. The pressure would drop and attempt to activate the other system. There was some PTU cavitation noted and it was corrected by recycling the PTU switch. At -65° F the PTU's did not maintain sufficient system pressure to perform the control sweeps (fig. 106, app E). The PTU's cavitated, overheated, and had to be shut down. Recycling the control switch did not alleviate the problem. The flight control hydraulic system met the

requirements of the PIDS (ref 9, app A) at ambient temperatures of -25° F to 125° F. The hydraulic system PTU's did not meet the PIDS requirement of satisfactory operation of individual hydraulic components in a local environment temperature range of -50° F to 160° F. The PTU's were slow to reach operating pressure at temperatures of -25° F, operated erratically at -50° F and were unsatisfactory at -65° F. The hydraulic PTU's erratic operation at -50° F is a deficiency.

40. The AFCS was qualitatively evaluated by nulling the DASH position error versus the longitudinal cyclic position. Detailed test techniques are outlined in appendix D. When both No. 1 and 2 systems were selected at 70° F the DASH actuator was driven to its null point at a low pre-engagement rate. When the null was reached the DASH caution lights were extinguished. At temperatures of -50° F and below the DASH was slower than normal to react but the system eventually nulled. On two occasions, however, at 125° F, both the No. 1 and 2 AFCS's failed to null the DASH. A test set was used to check the pitch control position transducer and the DASH actuator and no failures were detected. An AFCS computer check was performed using the built-in test equipment (BITE) and the errors detected were not related to the DASH failure. Temperatures in the avionics compartment were 158° F during the test (par. 28). The entire system operated satisfactorily at 70° F and attempts by BV to isolate the problem by heating individual components and identify the cause of the failure were unsuccessful. The dual failure of the AFCS at 125° F is a shortcoming.

41. A flight control system hysteresis and frequency response evaluation was conducted at each test temperature. A signal generator was used to produce a sinusoidal input to the ILCA. A description of the system and test procedure is in appendix D. Selected data are presented in phase and gain (Bode), time history and hysteresis plots (figs. 54 through 100, app E). At all temperatures the controls were exercised and each hydraulic boost system independently checked prior to the frequency response testing. The PTU's would not supply adequate pressure and flow to exercise the control at ambient temperatures below -25° F, so full control displacements were made after engine start to warm the hydraulic fluid. This technique could not be used with rotor blades installed without damage to the droop stops. The data reflects a total system phase shift of 45 degrees at 2 Hz at -65° F and approximately 3 Hz at 125° F ambient temperatures. The -6 db gain (half power) point for the total system varied from 8 Hz, with a hydraulic cooler input temperature of -23° C (-65° F ambient) to 20 Hz and with a cooler input temperature of 70° C (125° F ambient). Individual components reflected -6 db point from 16 to 22 Hz, at the respective temperatures. Time histories are presented of two frequencies at -65° F and 125° F (figs. 64 through 69, and 92 through 97, app E) and three frequencies at -50° F (figs. 70 through 78, app E). A shift in the mean value of the upper boost actuator outputs occurred at ambient test temperatures below -25° and at 125° F. The mean value would start high and shift below the zero reference with increasing frequency. The reverse trend was evident during some of the tests (figs. 69 and 66, app E). The reason for this shift could not be determined. The aft actuator did not respond to control inputs from the ILCA during two separate tests at -50° F ambient temperature. Figure 78 shows a step output in the first cycle which required an ILCA displacement of 0.05 inch to cause the actuator to continue the downward motion. The second cycle was clipped. The cooler input and output temperatures were -14° C and -18° C, respectively. A hysteresis test was conducted on a second test at -50° F and produced the same characteristics (fig. 81, app E). The cooler temperatures were -16° C for the input

and -21° C for the output. Hysteresis data were taken at all test temperatures and indicated a stepping motion in both the forward and aft swiveling actuators. Figures 79 through 81, and 98 through 100 reflect at least three cycles at each amplitude. In each test case the aft actuator has a greater lag than the forward actuator. Though not presented in the data, the crew experienced considerable airframe resonance during the frequency response testing at approximately 20 Hz. Within the scope of this test the flight control hydraulic system frequency response was satisfactory through -25° F. The aft actuator failed to respond to control inputs at -50° F. Further engineering flight testing below -25° F with rotor blades installed is recommended to accurately determine if the hydraulic fluid temperatures can be increased during run-up and maintained in flight at a level that would provide satisfactory flight control response. It is also recommended that the operator's manual specify a minimum temperature for aircraft operation.

Fuel System

42. The YCH-47D fuel system operation was monitored during the test temperature range of -65° F to 125° F. JP-5 fuel was used for ambient temperatures of -25° F and above and JP-4 for temperatures below -25° F. No abnormalities were observed throughout the program.

43. Refueling was accomplished with a standard pressure hose/nozzle arrangement fed through the test cell airlock from a fuel truck. Fuel samples were obtained from the fuel truck prior to delivery and from the aircraft after servicing and tested for compliance with MIL-T-5642L for JP-4 and JP-5 fuels. Defueling was accomplished using the defueling port located inside the aft section of the aircraft. Fuel was drawn from the tanks using the boost pumps and pressure-fed through a hose to storage tanks located outside the test chamber. Fuel remaining at the bottom of the bladders was removed through the sump drains.

Hydraulic System

44. The YCH-47D hydraulic system consists of two independent primary flight control systems and one utility system. A description of the aircraft hydraulic system is contained in appendix B and in the operator's manual (ref 3, app A). The hydraulic system was inspected prior to each run and monitored during the run to identify any leaks or system malfunctions. Fire-resistant hydraulic fluid MIL-H-83282A was used thoughout this evaluation. Hydraulic system data are presented in figures 101 through 108, appendix E.

45. The accumulator pressure indicators are small and difficult to read accurately. The face of the indicator, photo 6, is approximately one and one sixteenth inches in diameter with approximately three sixteenth of an inch representing a 1000 psi increment. As an example, the APU start accumulator has a maximum pressure of 3350 psi. This maximum pressure cannot be read within 100 pounds, however it is not as critical or difficult to read as the nitrogen precharge value. The precharge varies with temperature from 1500 to 2225 psi. When three sixteenth of an inch represents the pressure range of 2000 psi to 3000 psi it is impossible to identify a value of 2225 psi. The coarse scale and small size of the accumulator indicators are inconsistent with the stated allowable precharge pressures and are a shortcoming. The accumulator assemblies indicators should be marked with a zone of acceptable pressure to cover precharge variations with temperature.

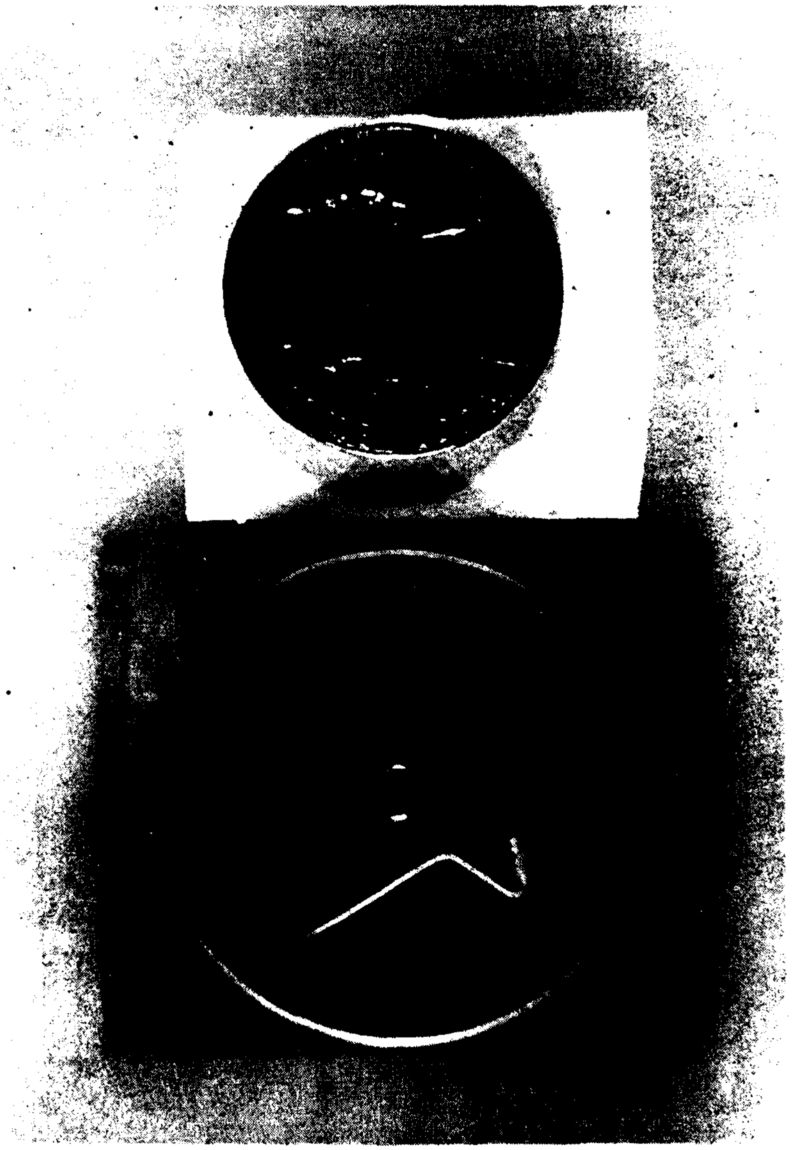
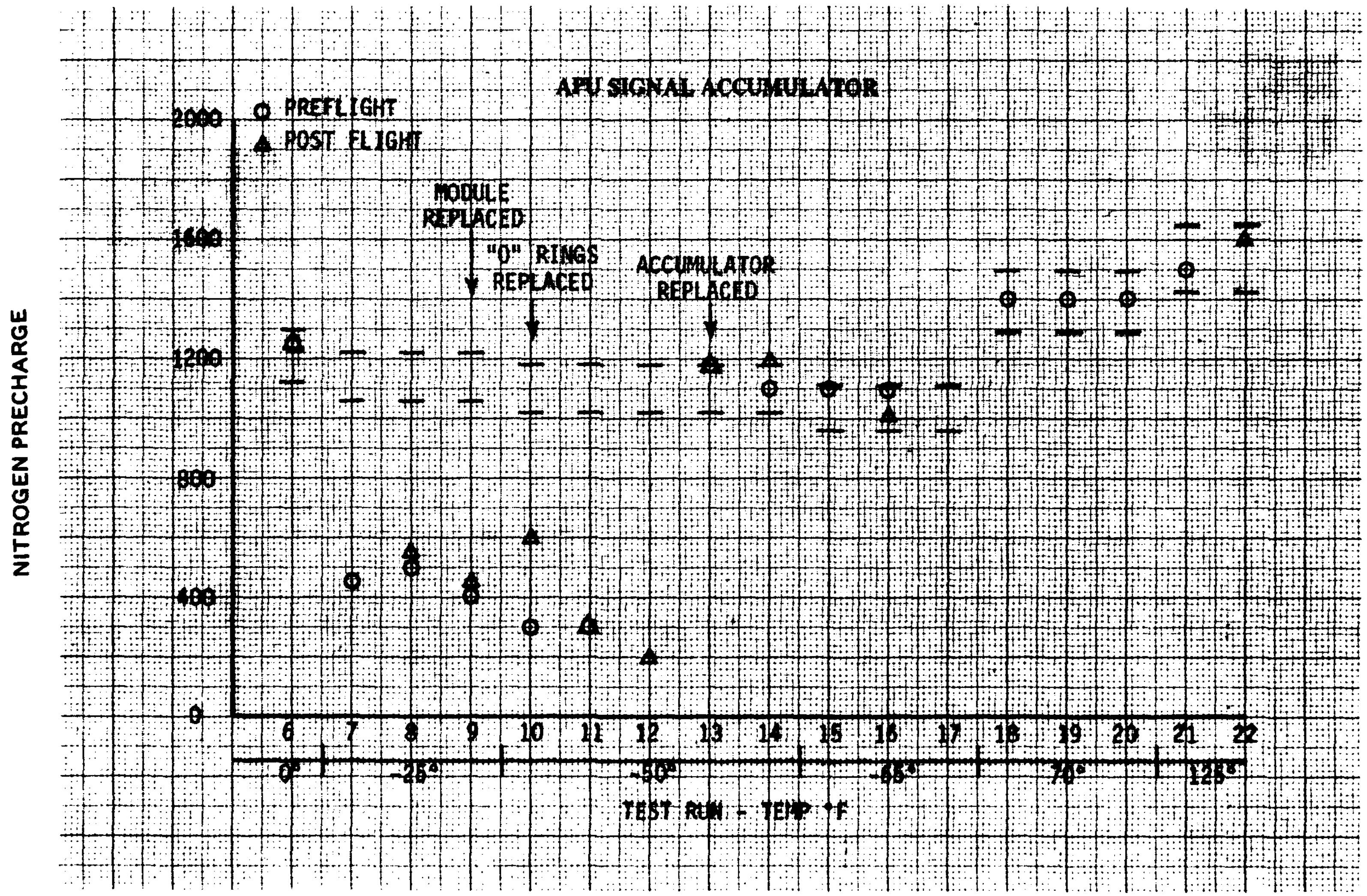


Photo 6. Hydraulic System Accumulator Gage

FIGURE 1
HYDRAULIC ACCUMULATORS
YCH-47D US ARMY S/N 76-8008



DASH LINES DENOTE HANDBOOK RANGE

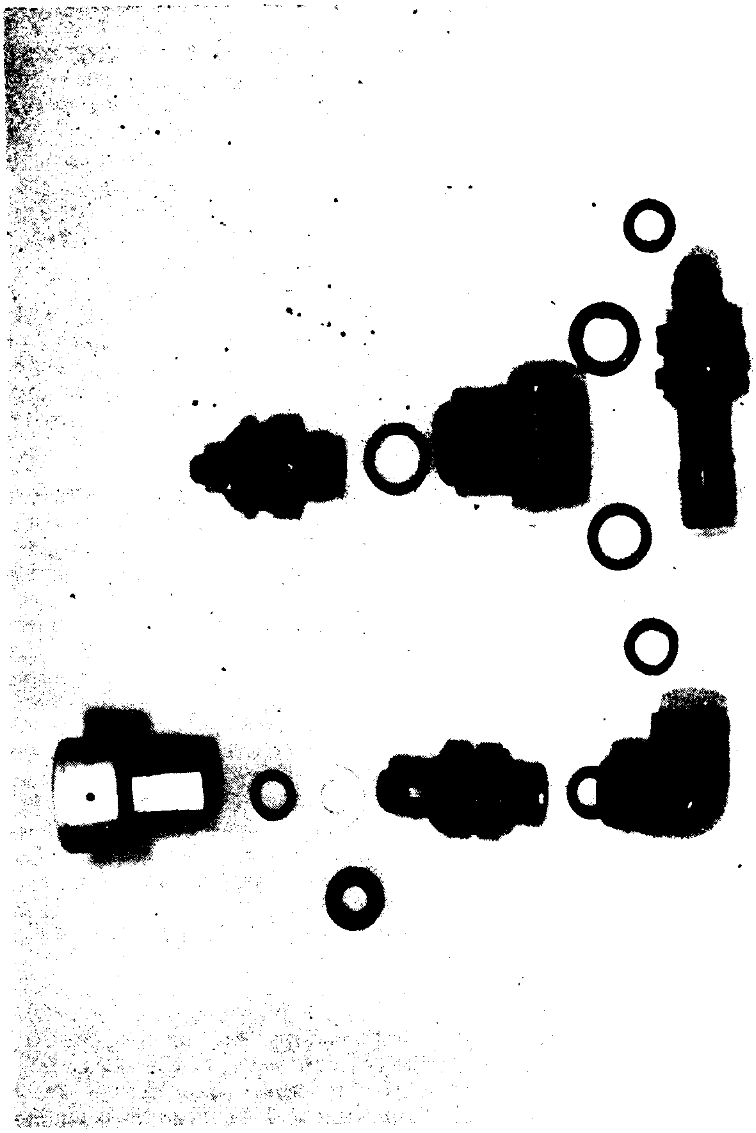


Photo 7. Shrader Valve/Gage Components

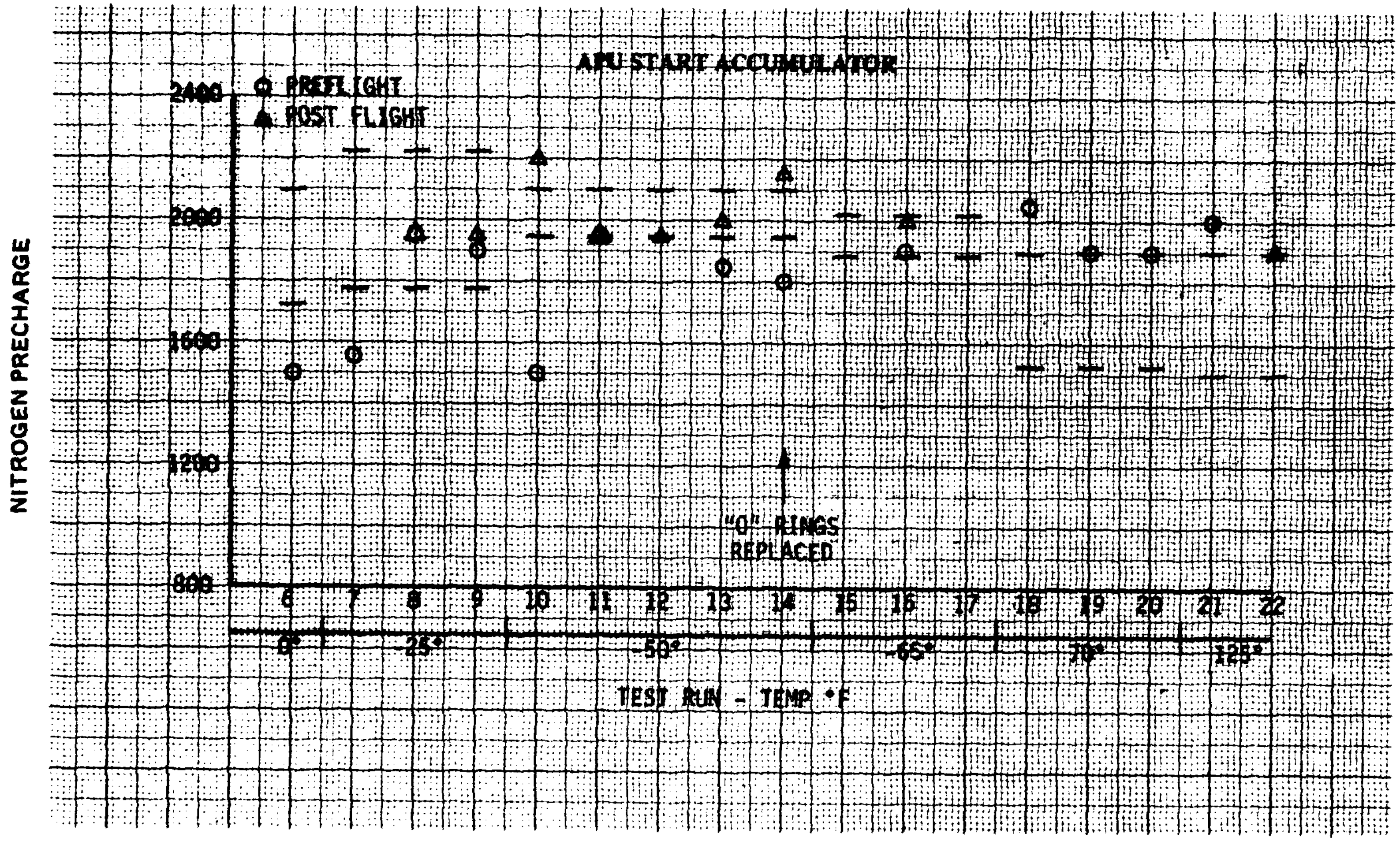
46. At temperatures below -25° F the accumulator assemblies generally failed to hold a precharge. A record of accumulator pre- and post-run pressures is included in appendix F. The APU signal accumulator's performance (fig. 1), is a typical example. Figure 1 presents the pre- and post-run precharge pressures versus run/temperature. Prior to run 9 the entire APU Start Module, which includes the signal accumulator, was replaced with no improvement noted. Prior to run 10 all "O" rings from the shrader valve and gage, were replaced. Oversized "O" rings were used to complete the testing. Prior to run 13 the signal accumulator, valve and gage were again replaced which apparently corrected the problem with the signal accumulator/start module. Photo 7 is a typical Shrader valve/gage installation on all accumulators and all had similar problems. The inability of the hydraulic system accumulator assemblies to hold a precharge below -25° F is a shortcoming.

47. The hydraulic accumulators precharge pressures do not remain within the handbook pressure tolerance band following a temperature change. Figure 2 presents the pre- and post-run pressures with handbook range versus run/temperature. The pressures were rarely within the tolerance band and it was necessary to service the accumulators before and after each run. The hydraulic system servicing required following a temperature change is a shortcoming.

48. The utility hydraulic two stage hand pump was evaluated for efficiency and ease of operation. This subsystem was found to be unsatisfactory at temperatures of -25° F and below, requiring in excess of 1000 cycles of the hand pump (approximately one hour of effort) to recharge the start accumulator. One-third of a stroke was effective at temperatures of -50° F. Use of the hand pump below -50° F was unacceptable without the application of heat to the assembly prior to an attempt. Also, the upstroke cycle on this pump was less efficient than the downstroke (normally 10 psi gain vs 30 psi gain), but ocassionally pressure was lost during the upstroke. Figure 3 presents a comparison of hand pump cycles required versus temperature. On the first APU start attempt at -65° F the start accumulator pressure response input to the APU MOTOR/PUMP was very slow and the APU achieved only 7 percent rpm (fig. 6, app E). The precharge was serviced prior to this test but was found to be at 0 psi after the start attempt. The start accumulator could not achieve or hold any pressure and was removed from the aircraft (EPR number 20, appendix G). The APU start accumulator was warmed to approximately 70° F and checked at a hydraulic laboratory facility. The accumulator was found to be operable and was reinstalled in the aircraft. There were no repeats of this problem. The unsatisfactory operation of the utility hydraulic two stage hand pump at -25° F and below is a shortcoming.

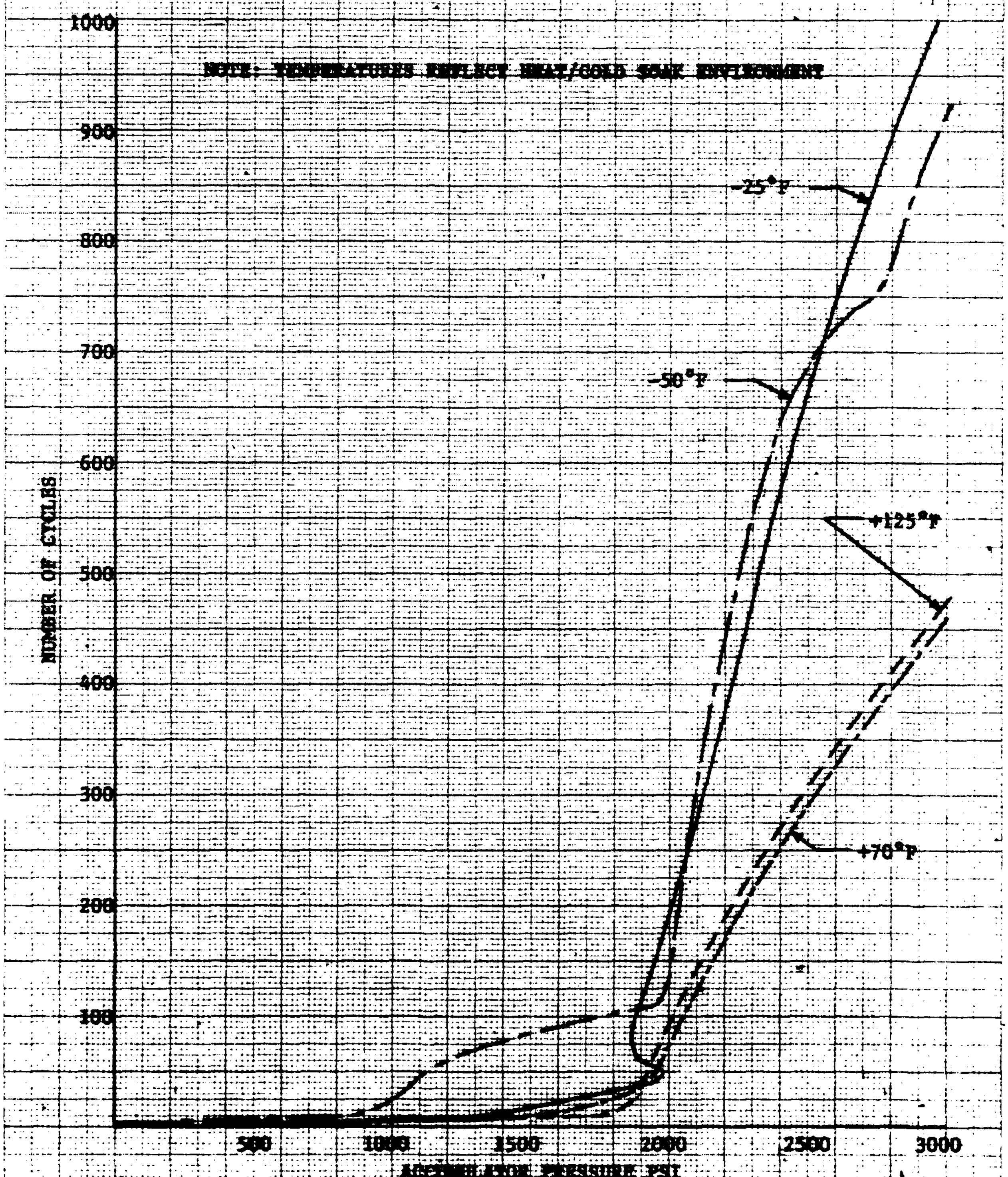
49. The No. 1 flight control reservoir cooler and the utility reservoir cooler were instrumented to monitor hydraulic fluid temperatures. The reservoir coolers have a cooling fan activated by a thermal switch which activates the fan at 63° C and deactivates it at 54° C. The utility reservoir cooler data reflect an average temperature differential between cooler in and out of 15° C at ambient temperatures of 0° F and above. However, the data at -25° F and below indicate there are periods where the temperature differential varies from 25 to 35° C with cooler out temperatures as low as -35° C (fig. 17). At 125° F the utility reservoir cooler fan was disabled by pulling the circuit breaker with no noticeable affect on the cooler out temperature. The No. 1 flight control reservoir cooler maintained a differential in/out temperature of approximately 10° C at ambient temperatures of 0° F and above. At -25° F and below the cooler out temperature remained in the -20° C range

FIGURE 2
HYDRAULIC ACCUMULATORS
YCH-47D US ARMY S/N 76-8008



DASH LINES DENOTE HANDBOOK RANGE

FIGURE 3
APU START ACCUMULATOR HAND PUMP EFFICIENCY
YCH-47D U.S.ARMY S/N 76-8008



while cooler in temperature reached 18° C at -25° F ambient and with excursions of as much as 30° C from the cooler out temperature. The hydraulic system combination reservoir/cooler appeared to be functional at cold temperatures. At 125° F the No. 1 flight control reservoir cooler fan was also disabled by pulling the circuit breaker. During both tests at 125° F the No. 1 flight control cooler temperatures approached 100° C and the test was terminated by repositioning the circuit breaker. Figures 107 and 108, appendix E reflect the cooler temperatures during the time when the cooler fans were disabled.

50. At all temperatures other than 70° F the flight control upper boost hydraulic actuator impending jam indicators had many nuisance extensions. Table 2 is a record of these extensions. The false indications of impending jam in the upper boost actuators, to be reset after each run, with no other indication of a failure is a shortcoming.

Miscellaneous

51. The test procedure, presented in appendix D, included a qualitative functional check of all components that could be operated in this test environment. All items operated generally satisfactory with the exception of the following:

a. The power steering failed to respond at -65° F ambient temperatures. When the swivels were unlocked and the power steering control activated the actuator would go hard over forcing the wheel to the left stop. The wheel was centered after each test and a similar failure occured during the remaining tests at -65° F.

b. Cargo Ramp operation was extremely slow at temperatures of -50° F and -65° F. It did, however, eventually close after a delay of several minutes following engine start.

c. The radar altimeter could not be set at the start of the run at temperatures below -25° F but operated normally at the end of each run.

d. The cabin door latch was extremely stiff and hard to close at temperatures below -25° F. It was determined that it had been lubricated with a heavy grease which contributed to the problem.

e. The crew chief's mike cord protective covering became rigid and shattered at temperatures below 0° F. It was replaced several times and finally was stored outside the test chamber between runs. Failure of the crew chief's mike cord protective covering at -25° F and below is a shortcoming.

Rotor System

52. The rotor blades were removed and stored prior to the aircrafts entry into the engine test cell at the Climatic Laboratory. Two blades, one from the forward head, S/N A-1-013, and one from the aft head, S/N A-2-023, were placed in the test chamber on a special dolly for the duration of this evaluation. These blades were inspected at each temperature for general condition, voids, delamination, etc., and no discrepancies were noted as a result of the temperature profile of 70° F to -65° F to 125° F. No discrepancies were noted with the rotor heads during this evaluation.

TABLE 2
FLIGHT CONTROL HYDRAULIC ACTUATOR IMPENDING JAM INDICATORS

○ Extended During PTU Check
▽ Extended During Test Run

FLIGHT CONTROL ACTUATOR	FWD PIVOTING		FWD SWIVELING		AFT PIVOTING		AFT SWIVELING	
HYDRAULIC CONTROL SYSTEM	1	2	1	2	1	2	1	2
TEST RUN #4 @ 0°F			▽	▽				
TEST RUN #5 @ 0°F	○							
TEST RUN #6 @ 0°F			○					
TEST RUN #7 @ -25°F		○ ▽			▽	▽		
TEST RUN #8 @ -25°F			▽	▽		○ ▽	▽	
TEST RUN #9 @ -25°F	▽			▽		▽		
TEST RUN #10 @ -50°F		APU	○ RUN	○ ONLY				
TEST RUN #11 @ -50°F						▽		▽
TEST RUN #12 @ -50°F								▽
TEST RUN #13 @ -50°F			▽	▽		▽		
TEST RUN #14 @ -50°F			▽	▽				▽
TEST RUN #15 @ -65°F	▽	▽	▽	▽	▽	▽		▽
TEST RUN #16 @ -65°F	▽	▽	▽	▽	▽	▽		▽
TEST RUN #17 @ -65°F	▽	▽	▽	▽	▽	▽		▽
TEST RUN #18 @ +70°F								
TEST RUN #19 @ +70°F								
TEST RUN #20 @ +70°F								
TEST RUN #21 @ +125°F	▽		▽			▽		
TEST RUN #22 @ +125°F	▽		▽					

Transmissions

53. The YCH-47D is a twin engine twin rotor aircraft with the resultant transmissions and shafting required for normal operation. The aircraft has a total of five transmissions, consisting of a forward, aft, combining and two engine nosebox transmissions. Data are presented in figures 109 through 115, appendix E. The transmissions generally functioned well during this evaluation. Following each run, oil samples were taken from each transmission and submitted to an Air Force Fuels Laboratory, for spectral analysis to determine the percent of metallic content in the sample. No unacceptable levels of contamination were found. The start up system pressures were higher at colder temperatures with the forward transmission exceeding all the others. The forward transmission reached approximately 465 psi on start at -65° F ambient temperature. Figure 114, appendix E presents this data at -65° F.

54. During shutdown following the second test at 0° F a slipping sprag clutch was suspected to be the cause of a double main generator failure. The circumstances which led to this conclusion are discussed in paragraph 26.

55. A second problem appeared at -50° F when the number 2 nosebox oil cooler thermal bypass valve stuck in the closed position. The result was a higher than normal oil temperature and oil pressure approaching minimum. The thermal valve was dislodged on one occasion with a vigorous whack and performed normally for the rest of that run. However, this technique was unsuccessful during the remainder of the testing. All efforts to solve this problem were futile. Upon discovery of this phenomenon on the first run at -50° F, a new thermal bypass assembly was shipped from BV and installed for the subsequent run. The replacement valve, however, was found to be defective and the oil pressure dropped to minimum during the run, forcing a premature termination. As a result, the original thermal bypass valve was adjusted to increase system pressure approximately 10 psi and the unit was reinstalled. Subsequently, at test cell temperatures of -50° F and -65° F, the No. 2 nosebox temperature typically rose to between 97° and 100° C (No. 1 nosebox temperature was approximately 71° C) with corresponding pressures approximately 25 psi. The data presented in figures 112 and 113, appendix E reflect the temperature profile of this anomally. A plot of both nosebox temperatures and pressures are included in figure 4. Failure of the number 2 nosebox oil cooler thermal bypass valve in the closed position at temperatures of -50° F and below is a shortcoming.

56. Transmission servicing was found to be a difficult and somewhat annoying problem. Servicing was performed in accordance with the maintenance manual (ref 10, app A) which requires oil levels to be maintained at the center of the sight glass. Following the test at -25° F the oil was changed from MIL-L-23699 to MIL-L-7808 in all transmissions. A record of the quantity of fluid removed was not kept but servicing to the indicated full level did not agree with the quantities called for in the manual. Records were maintained from that point on and are reflected in table 3. On a typical run the servicing indications were recorded and are presented in figures 5 and 6 for the aft, combining and No. 1 and No. 2 transmissions. The preflight level indication (cold reading), was noted and the transmissions were then serviced to the center of the glass. Following the run the indications were recorded every 5 minutes for a total of 30 minutes. The figures clarify the servicing problem. The useable quantity of oil in each transmission should be checked and reflected in applicable manuals. A servicing technique should be developed which

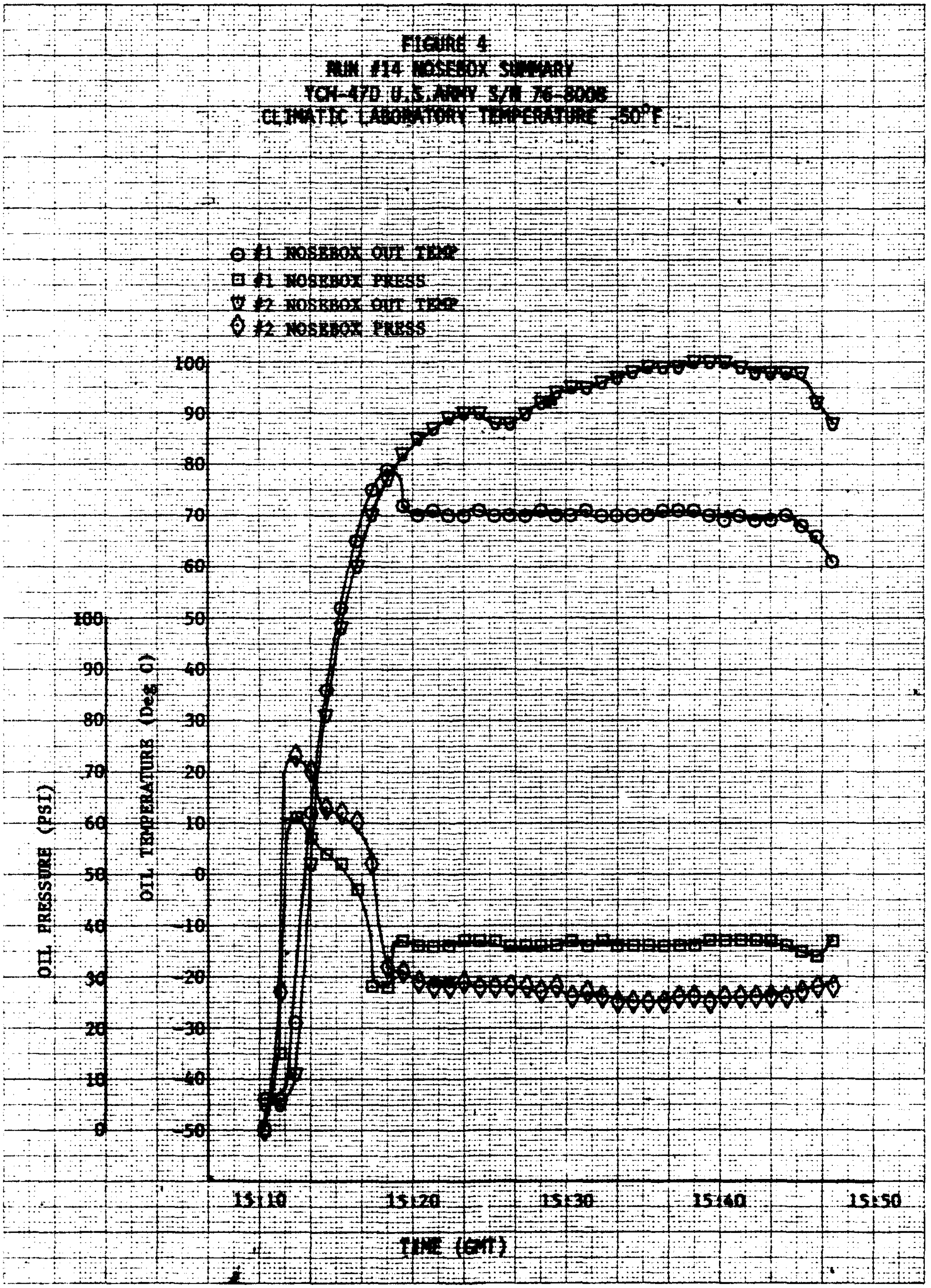


FIGURE 4
RUN #14 NOSEBOX SUMMARY
YCH-47D U.S.ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50°F
#1 NOSEBOX OUT TEMP
#1 NOSEBOX PRESS
#2 NOSEBOX OUT TEMP
#2 NOSEBOX PRESS
OIL PRESSURE (PSI)
OIL TEMPERATURE (Deg C)
15:10
15:20
15:30
15:40
15:50
TIME (GMT)

TABLE 3
AIRCRAFT TRANSMISSION SERVICING [1]

	Fwd Main	Aft Main	Comb XMSN	No.1 Eng	No.2 Eng		Fwd Main	Aft Main	Comb XMSN	No.1 Eng	No.2 Eng
	TRANSMISSION CAPACITIES (QUARTS)										
DEPTM 55-1520-240-23	26.7	43	19.2	11	11		26.7	43	19.2	11	11
	TRANSMISSION SERVICING DURING TESTS										
	Quarts Drained						Quarts Added				
Post Run #9 Oil Changed [2]							23	26	16	16	6
Pre Run #10 (APU Run Only)							+4	+2		+2	+1
Pre Run #12								+2			
Pre Run #13								+2			
Pre Run #15										+1	
Post Run #17 Oil Changed [3]	17	23	15	8	4		16	24	13	8	6
Pre Run #13		-1									
Post Run #18							+3	+2			
Pre Run #19										+2	
Post Run #19			-2								
Pre Run #21	-3	-2								+1	+1
Pre Run #22										+1	
Post Run #22 Oil Changed [4]	16	27	18	6	6						

NOTES:
1. Oil servicing procedures in accordance with DEPTM 55-1520-240-23. Levels serviced to the center of the sight glass.
2. Oil changed from MIL-L-23699B to MIL-L-7808H for operations below -25°F.
3. Oil changed from MIL-L-7808H to MIL-L-23699B for operations above -25°F.
4. Oil changed to MIL-L-7808H for flight.

FIGURE 5
TRANSMISSION SERVICING
YCH-47D U.S. ARMY S/N 76-8008
AFT TRANSMISSION

SHADED SYMBOL INDICATES OUT OF GLASS LOW.

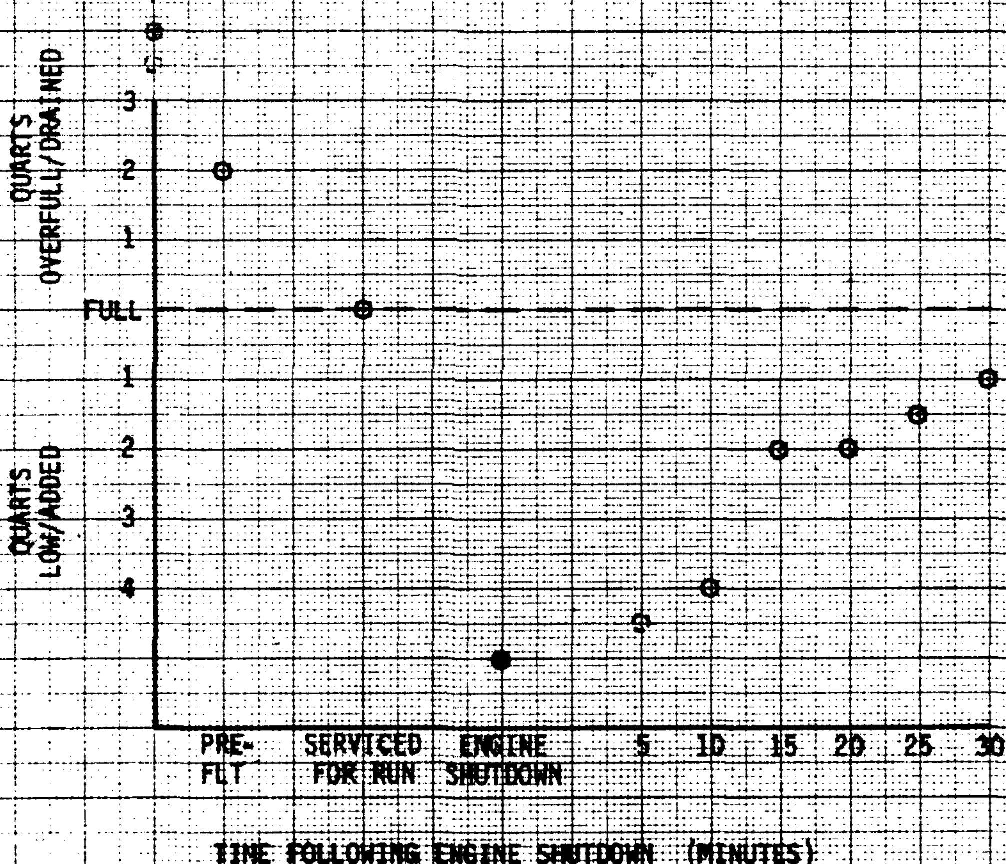
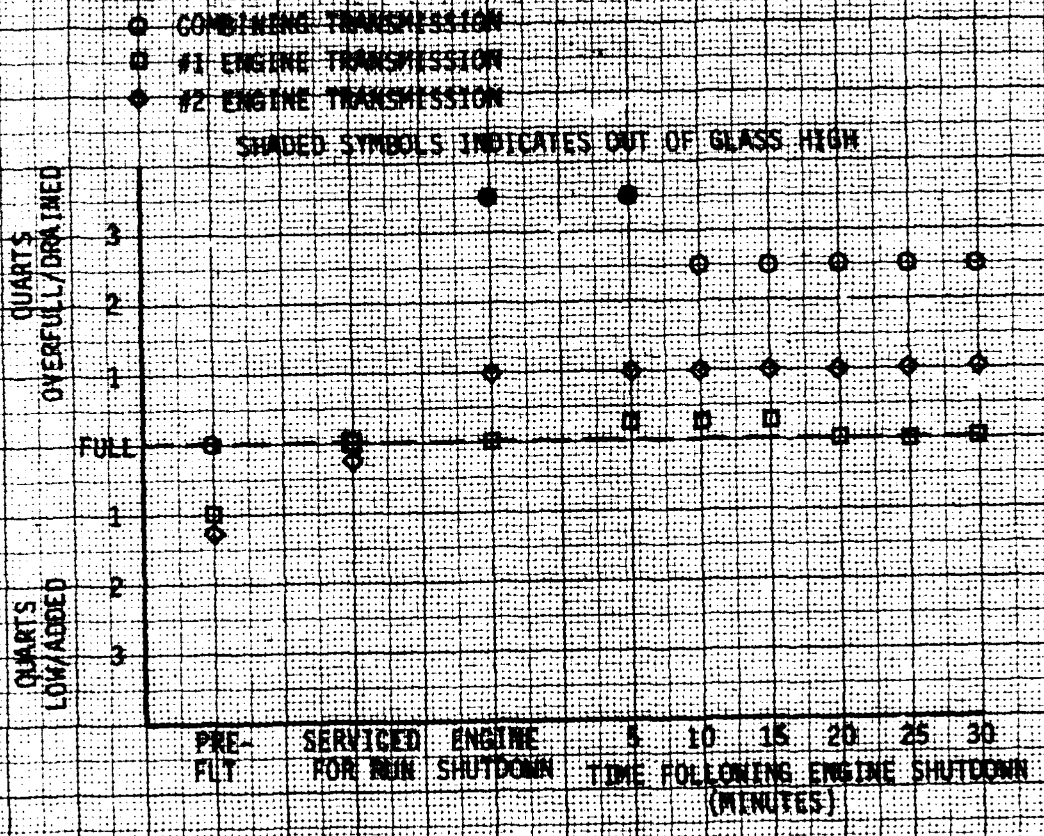


FIGURE 6
TRANSMISSION SERVICING
YCH-47D U.S. ARMY S/N 76-8008
COMBINING, NO. 1 & NO. 2, TRANSMISSIONS



can accommodate varying fluid levels with temperature, *i.e.*, a hot level servicing indication as well as a cold level indication. The unreliable transmission oil level indication is a shortcoming.

57. The forward transmission input seal was replaced during the climatic laboratory evaluation. This seal had previously been replaced during the YCH-47D icing evaluation. Only 47 hours had been flown since the previous seal change. The apparent short life of the forward transmission input seal is a shortcoming.

HUMAN FACTORS

58. The temperature extremes required by the scope of this program accentuated the loss of motor efficiency of personnel directly involved with the operation and maintenance of the aircraft. It was noted that, at temperatures below 0° F, aircraft preparation proceeded at a more restrained pace. Also, winter flying garments were a hindrance in the performance of normal maintenance and flight crew duties. Operation of the APU start accumulator hand pump had become more tedious both in the amount of force required for operation and the extended length of time required to attain appropriate recharge pressure (para 47). At 125° F, extreme caution was exercised to prevent heat exhaustion; therefore, it was necessary to curtail activity within the test cell. Due to the confined nature of the engine and APU exhaust ducting with respect to the test cell, a great build-up of heat (up to 175° F) was encountered at the aft section of the aircraft.

RELIABILITY AND MAINTAINABILITY

59. RAM data were collected by personnel of AVNDTA. The results of their findings will be published as a separate report.

CONCLUSIONS

GENERAL

60. The YCH-47D aircraft performed acceptably from -25° F to 125° F and exhibited potential for operation at temperatures of -50° F. The exceptions were APU failure to start on first attempt at -25° F and the dual AFCS failure at 125° F (para 10).

SPECIFIC

61. The following specific conclusions are included:

a. Testing without blades in a small chamber reduced the scope of the test and makes the applicability of many of the results to operational units questionable (para 10).

b. Excessive lateral control forces at temperatures of -25° F and below may affect flight operation and safety (para 38).

c. Flight control system warm-up and operation using the APU to supply hydraulic pressure via the power transfer units is unsatisfactory at temperatures of -50° F and below (para 39).

d. The hydraulic power transfer units were slow to reach operating pressure at temperatures of -25° F and below (para 39).

e. The hydraulic system combination reservoir/coolers appear to be functional at cold temperatures and the data indicate cooler out temperatures of approximately -35° C (para 49).

f. The flight control hydraulic system frequency response was satisfactory through -25° F, however, the aft actuator failed to respond to control inputs at -50° F (para 41).

g. Two deficiencies and fourteen shortcomings were noted.

ENHANCING CHARACTERISTIC

62. The T55-L-712 engines installed in the YCH-47D started satisfactorily at temperatures of -65° F to 125° F including satisfactory shutdown with immediate restart at -50° F and 125° F (para 23).

DEFICIENCIES

63. The following deficiencies were identified within the temperature range specified in the Prime Item Development Specification (ref 9, app A).

a. The inability of the ECL to control engine acceleration during start due to moisture in the ECL box (para 24).

b. The hydraulic PTU's erratic operation at -50° F (para 39).

SHORTCOMINGS

64. The following shortcomings were identified and are listed in decreasing order of relative importance:

a. Excessive control forces below -25° F (para 38).

b. The inability of the hydraulic system accumulator assemblies to hold a precharge at temperatures below -25° F (para. 46).

c. The unsatisfactory operation of the utility hydraulic two stage hand pump at -25° F and below (para 48).

d. The dual failure of the AFCS at 125° F (para 40).

e. Failure of the APU ECU at 125° F ambient temperature (para 19).

f. Failure of the No. 2 nosebox oil cooler thermal bypass valve in the closed position at temperatures of -50° F and below (para 55).

g. The unreliable transmission oil level indication (para 56).

h. The coarse scale and small size of the accumulator indicators are inconsistent with the stated precharge pressure (para 45).

i. The cabin and cockpit temperatures at -25° F and below are uncomfortable, fatiguing to the crew (para 31).

j. The false indications of impending jam in upper boost actuators (para 50).

k. The apparent short life of the forward transmission input seal (para 57).

l. Failure of the crew chief mike cord protective covering at -25° F and below (para 51).

m. At temperatures below 0° F a cold soaked battery was unable to provide adequate power to open the APU pilot valve solenoid in the APU start module (para 36).

n. The hydraulic system servicing required following a temperature change (para 47).

65. The following problems were identified within the temperature range tested but outside the requirements of the PIDS:

a. The hydraulic PTU's failure to pressurize the flight boost system at -65°F (para 39).

b. The failure of the power steering system to operate at -65° F (para 51).

Operation of the aircraft at temperatures below -50°F would require these problems to be identified as a deficiency in the case of the PTU's failure to pressurize the flight boost system and as a shortcoming for the power steering failure.

RECOMMENDATIONS

66. The deficiencies identified in paragraph 63 must be corrected.

67. The shortcomings listed in paragraph 64 should be corrected.

68. The APU starting characteristics should be improved for reliable operation below 0° F (para 18).

69. A servicing technique should be developed for the transmissions which can accommodate varying fluid levels with temperature (para 56).

70. The accumulator assemblies indicators should be marked with a zone of acceptable pressure to cover precharge variations with temperature (para 45).

71. Further testing with blades installed should be accomplished to determine if the aircraft is operationally able to fly at temperatures below -25° F (para 38).

72. The operator's manual specify a minimum temperature for aircraft operation (para 41)

73. Further engineering flight testing below -25° F with rotor blades installed is recommended to accurately determine if the hydraulic fluid temperatures can be increased during run-up and maintained in flight at a level that would provide satisfactory flight control response (para 41) and evaluate the use of MIL-H-5606 hydraulic fluid at the lower temperature.

APPENDIX A. REFERENCES

1. Letter, AVRADCOM, DRDAV-DI, subject: YCH-47D Climatic Laboratory Survey, 4 April 1980.

2. Test Plan, USAAEFA Project No. 79-13, *Climatic Laboratory Evaluation, YCH-47D Helicopter*, April 1980.

3. Technical Manual, DEPTM 55-1520-240-10, *Operator's Manual, Army Model YCH-47D Helicopter*, 21 March 1980.

4. YCH-47D Special Operating Instructions for Climatic Laboratory Evaluation dated 4 September 1980.

5. Military Specification MIL-E-5272C, Environmental Testing, Aeronautical and Associated Equipment; General Specification For, 13 April 1959.

6. Military Specification MIL-I-5289B, Instrumentation Installation for Climatic Test of Aircraft; General Specification For, 11 August 1955.

7. Pamphlet, Army Materiel Command AMCP 706-23, "Engineering Design Handbook, Helicopter Engineering, Part Three, Qualification Assurance, "April 1972.

8. USAASTA Project Document No. 73-41, *Instrumentation Specifications for Climatic Laboratory Tests*, August 1973.

9. Prime Item Development Specification, Boeing Vertol Company, No. 145-PJ-7103, "Model YCH-47D Helicopter," 20 June 1975 with revision on 17 May 1979.

10. Technical Manual, DEPTM 55-1520-240-23, *Maintenance Manual YCH-47D Helicopter*.

APPENDIX B. AIRCRAFT DESCRIPTION

GENERAL

1. The YCH-47D is a twin-turbine engine, tandem rotor helicopter (photo 1) designed for troop and internal/external cargo transport during visual and instrument, day and night operations. It is powered by two T55-L-712 shaft-turbine engines housed in pylons mounted on each side of the aft fuselage. The engines drive tandem, three-bladed, fully articulated, counter-rotating rotors. The drive train system consists of two engine transmissions, a combining transmission and a forward and aft transmission. A T62-T-2B gas turbine auxiliary power unit, mounted in the aft pylon, drives a hydraulic pump and a 20 KVA generator to provide power to the aircraft systems when the rotors are stationary. Fuel is carried in six tanks holding approximately 7000 pounds of fuel mounted in pods on each side of the fuselage The helicopter is equipped with four non-retractable landing gears with steering provided by the right aft gear. Entrance to the helicopter is provided through a door located on the forward right side of the cargo compartment or through a hydraulically-operated cargo ramp located at the rear of the cargo compartment. The helicopter is equipped with standard tandem rotor cockpit controls and an advanced flight control system (AFCS). The allowable center of gravity (cg) envelope is contained in the operator's manual (ref 3, app A). The maximum gross weight is 50,000 pounds.

FLIGHT CONTROLS

General

2. The irreversible, electrohydraulic flight control system is powered by two independent hydraulic boost systems, each operating at 3000 psi pressure. Control inputs from the cockpit are transmitted through mechanical linkage to the integrated lower control actuator (ILCA) which then transmits individual axis-oriented control motions to the mechanical mixing units. The mixed outputs are then transmitted through a series of push-pull tubes to the two upper dual-boost actuators attached to the forward and aft swashplates.

Advanced Flight Control System (AFCS)

3. Automatic inputs from the AFCS enter the flight control system by two means:

a. In series, between the cockpit controls and the rotors, through the ILCA and the differential airspeed hold (DASH). These signals do not move the cockpit controls.

b. In parallel, with the collective controls through a collective control drive actuator (CCDA). These signals move the cockpit collective controls.

4. The AFCS provides the following modifications and additions to the stability augmentation system (SAS) installed in earlier model CH-47 helicopters.

a. Continuous pitch attitude and, in the long term, airspeed hold referenced to the longitudinal control position throughout the flight envelope.

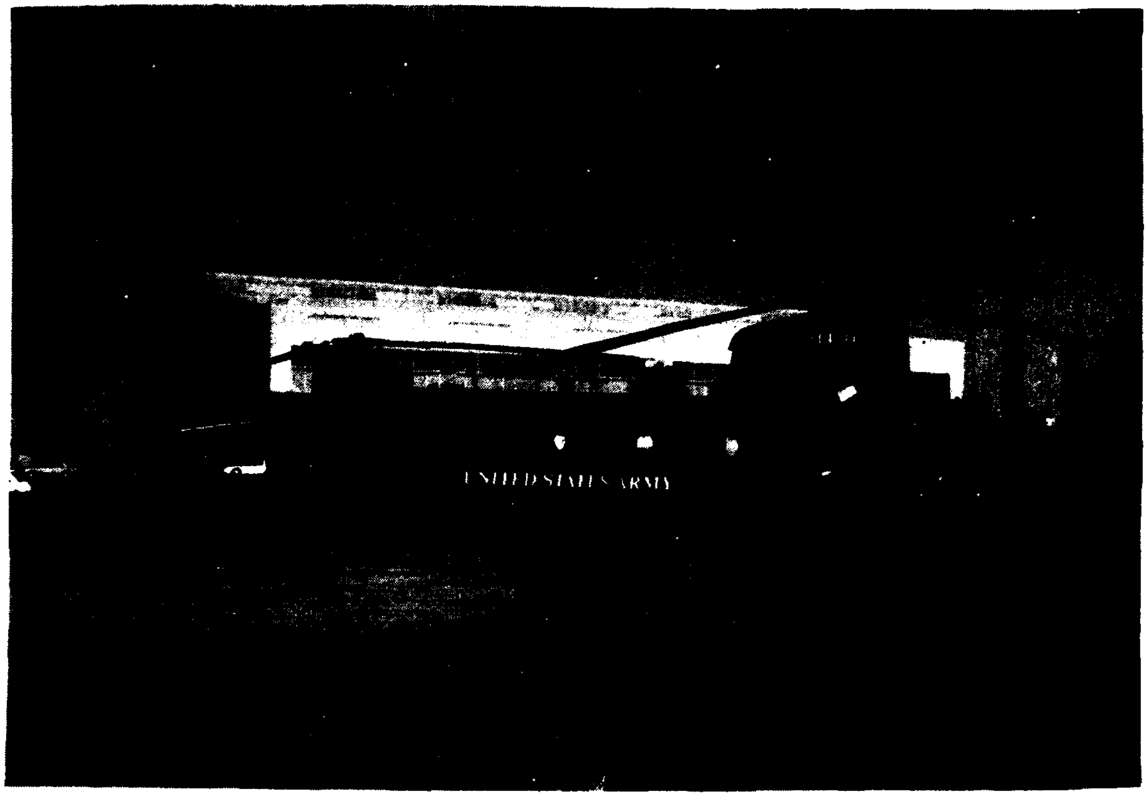


Photo 1. YCH-47D USA S/N 76-8008

b. Long term bank angle- and heading-hold in level flight and bank angle hold about any stabilized bank angle in turning flight.

c. A stable longitudinal control gradient from maximum rearward to maximum forward flight airspeeds.

d. Vernier beep trim of bank angle and airspeed.

e. Radar and barometric altitude hold.

f. Coupled heading selected through the radio magnetic indicator (RMI) bug error.

g. Cockpit control position transducers (control stick pick-offs) in the longitudinal, lateral and directional control systems to improve maneuverability.

h. The mechanical detent switches on the lateral and directional controls have been replaced by electronic signals derived from control position signals supplied to the AFCS.

i. Automatic longitudinal cyclic trim positioning to the ground mode when both aft wheels are on the ground.

j. New model flight control actuators are used.

ROTOR BLADES

5. The fiberglass rotor blades are of 30-foot radius with a 32-inch chord and are designed to operate at 225 rpm. Blade planform has a constant-chord between station 97 and the tip; from station 97 inboard, it transitions to a circular root end section. The blades have a 12 percent thick VR-7 airfoil out to 85 percent radius, tapering uniformly to a 8 percent thick VR-8 airfoil at the tip. The twist is -12 degrees.

6. The blades are of fiberglass construction with a nomex honeycomb core. The "D"-shaped spar is constructed of fiberglass, reinforced composite terminating at the root end in a "wrap-around" single pin joint. The nose of the spar includes balance weights and provisions for a de-ice heat blanket. Outboard, the spar contains provisions for forward and aft weight fittings. The airfoil fairing aft of the spar is formed from a banded sub-assembly of non-metallic honeycomb core covered with cross-plied (±45 degrees) fiberglass skins. The fiberglass trailing edge member has a built-in "cusp" angle. A titanium leading edge cap is incorporated to provide leading edge damage tolerance, erosion protection and lightning protection. A replaceable electro-formed nickel protective cap is installed from the 85 percent radius to the tip. The blades were removed for this test.

ENGINES

7. The T55-L-712 engine was designed to incorporate improved maintainability and performance capability when compared with earlier T55 models. The engine also has the capability to produce emergency power on pilot demand. Power levels

for non-installed, sea level, standard static conditions and 15,066 engine rpm (225 rotor rpm) are presented below:

Emergency power (30 min, cumulative)	4320 shp
Maximum power (10 min)	3704 shp
Intermediate power (30 min)	3370 shp
Maximum Continuous power	2987 shp

Engine Start System

8. The engine start system includes the hydraulic starters on each engine, the engine start valves and the solenoid-operated pilot valves on the utility system pressure control modules, the START switches and caution lights, the ignition LOCK switch, and the start fuel solenoids and ignition exciters on the engines.

9. When the start switch is moved to MOTOR, the START caution light comes on and the start valve opens. The start valve applies utility system pressure from the APU to the engine starter; rotating the engine starter and compressor. At 10 percent N1, the engine condition lever is moved to GROUND. The start switch is immediately moved to START, energizing the ignition exciter. Start fuel is sprayed into the combustor and combustion begins. Prior to power turbine inlet temperature (PTIT) reaching 450° C, the Start switch is manually released to MOTOR. At MOTOR, the start fuel valve is closed and the ignition exciter is deenergized. The start valve remains open, however, and the starter assists the engine until starter cutout speed of 50 percent N_1. The engine then accelerates to a ground idle speed. At ground idle, the START switch is manually moved to the locked off position. At OFF, the pilot valve closes, closing the start valve and deenergizing the START caution light. A relay in each engine start circuit is energized when either START switch is at MOTOR or START. The relay, when energized, disables the start circuit of the opposite engine, preventing simultaneous dual engine starts.

POWER TRAIN SYSTEM

General

10. Engine power is supplied to the rotors through a mechanical transmission system. This system consists of a forward, an aft, a combining, two engine transmissions and drive shafting. An overrunning sprag clutch is installed in each engine transmission. The clutch provides a positive drive connection to transmit power and permits freewheeling of both rotors, in autorotation during actual or simulated power failure. Because of the freewheeling feature, no drag will be placed on the rotors if an engine (or engines) or engine transmission fails. Power from the engine transmissions is transmitted through separate drive shafts to the combining transmission. The combining transmission combines the power of the engines and transmits it at reduced shaft speed to the forward and aft transmissions.

11. Two AC generators, the No. 2 flight control hydraulic pump, and the utility hydraulic system pump are mounted on and driven by the aft transmission. The No. 1 flight control hydraulic system pump is mounted on and driven by the forward transmission.

12. The combining transmission receives power from the engine transmissions and drives the forward transmission through drive shafting housed in a tunnel along the top of the fuselage. The aft transmission is driven by a drive shaft running from the aft section of the combining transmission. The YCH-47D transmission system includes features to reduce vulnerability and improve reliability. The forward, aft and combining transmissions having integral cooling blowers and heat exchangers. In addition to separate oil systems, an auxiliary (redundant) source of lubrication, designed to maintain safe operation for two hours, is provided. The forward, aft and combining transmissions are also designed to operate for 30 minutes after loss of both main and auxiliary oil pressure. The improvement in reliability designed in the system is achieved by use of improved material, increased gearing and bearing capacity, increased bearing life, reduced shaft and spline stress levels and tuning of dynamic components to reduce motion amplitudes.

Transmission Lubrication

Forward Transmission:

13. The forward transmission lubrication system includes independent main and auxiliary systems which operate concurrently. An oil cooler mounted on the aft end of the transmission around the input pinion cools main system oil. Air is forced through the cooler by a transmission-driven fan.

Aft Transmission:

14. The aft transmission lubrication system supplies lubricating oil to the various gears and bearings in the aft transmission and to the aft rotor shaft bearing. In addition, the main lubrication system circulates cooling oil through the two AC generators on the aft transmission. The aft transmission includes two lubrication systems: a main system and an auxiliary system which operate concurrently. An oil cooler mounted on the aft end of the transmission cools main system oil. Cooling air is drawn through the cooler by a transmission-driven fan.

Combining and Engine Transmissions:

15. The combining transmission has independent main and auxiliary lubrication systems which operate concurrently. The oil coolers for the combining and both engine transmissions are mounted on the combining transmission. Cooling air is forced thru the coolers by a transmission driven fan.

HYDRAULIC SYSTEMS

16. The hydraulic systems consist of dual modularized flight control systems and a modularized utility hydraulic system (figs. 1 and 2). Both flight control systems operate at 3000 psi and separately and independently operate the dual upper control actuators and ILCA's. The systems are modularized (pre-packaged hydraulic components having a standard outline) and provide two power modules, two reservoir/cooler modules, two fans, two lower control pressure control modules, two transmission mounted pumps, two power transfer units and a hydraulic maintenance panel. The utility system provides hydraulic power for both flight and ground utility functions and ground checkout of the flight control system. The forward trans-

UTILITY HYDRAULIC SYSTEM SCHEMATIC

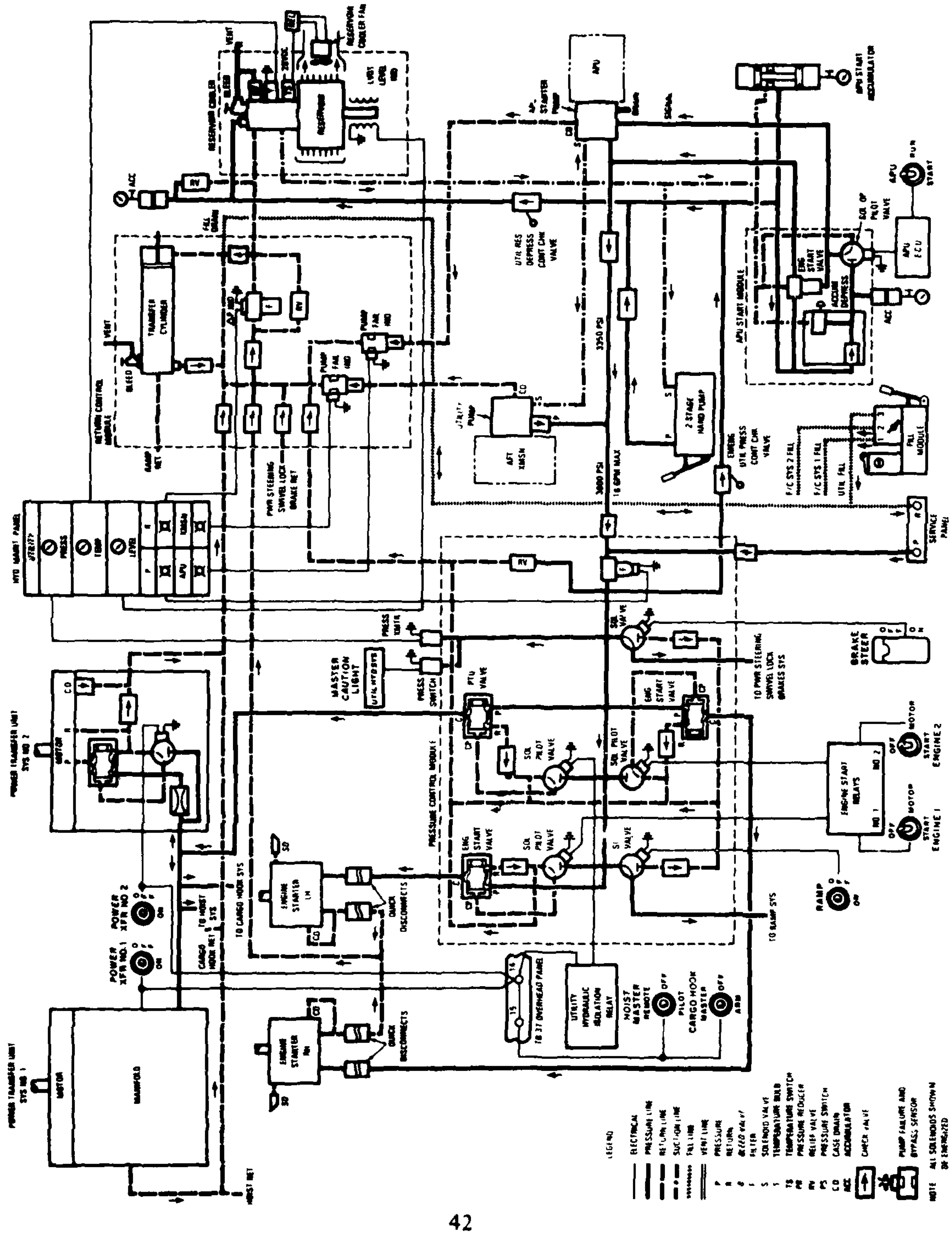


Figure 1

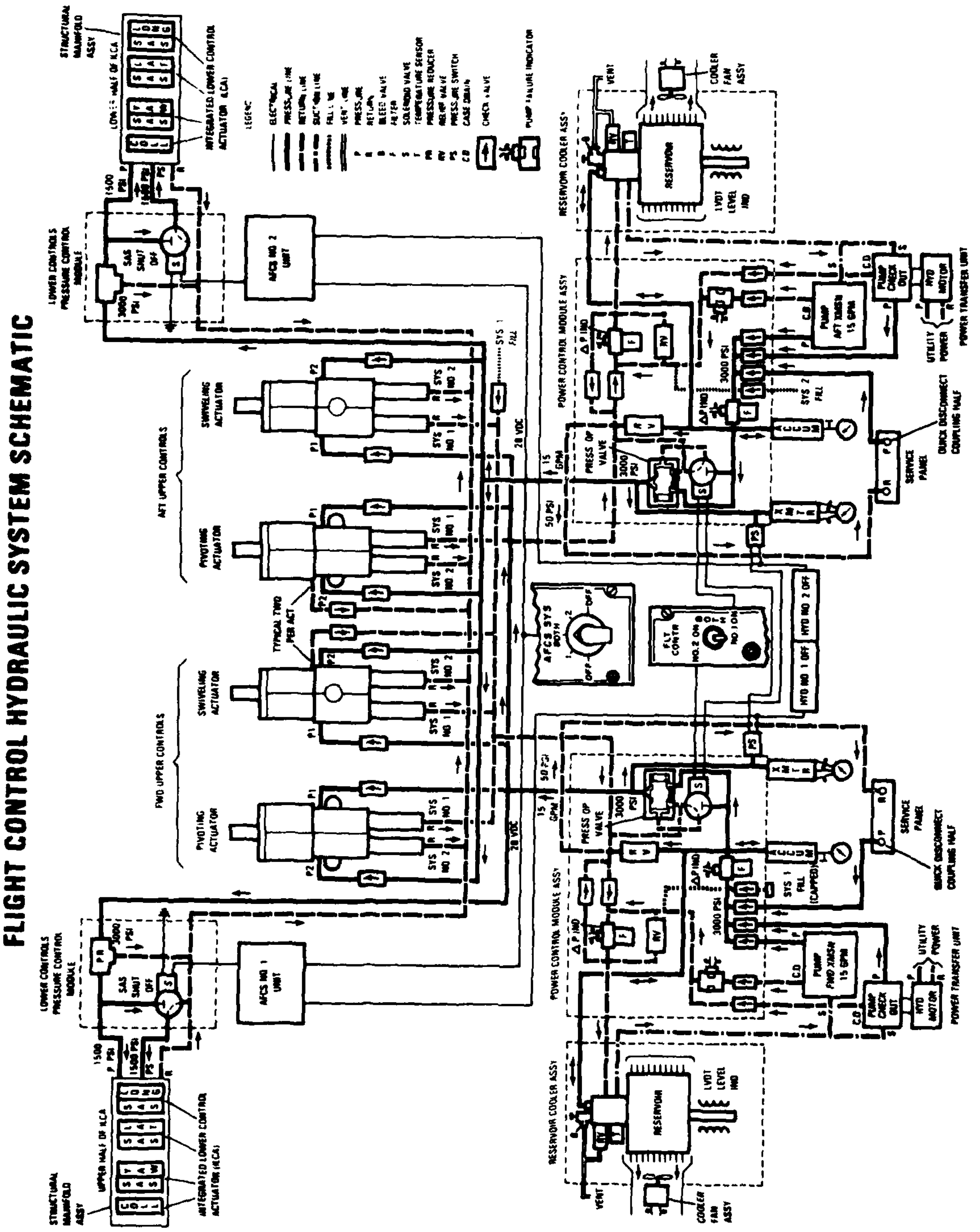


Figure 2

mission drives the number one hydraulic control system while the aft transmission drives the number two system.

ELECTRICAL SYSTEMS

17. The YCH-47D electrical system is designed to be a first fail-operative, second fail-safe system capable of serving all required electrical loads during flight and ground operation. The primary electrical system is rated at 115/200 volts, 400 Hz alternating current. Electrical power is furnished by two AC, oil-cooled, brushless, 40 KVA generators mounted on the aft transmission. The APU drives a 20 KVA generator which provides power for ground service and checkout functions. The AC bus system provides electrical isolation of generator outputs. DC power is supplied by two transformer rectifier units (TRU), each connected to an isolated bus. TRU's are physically isolated to reduce vulnerability; a bus tie relay automatically ties the two buses together in the event of failure in either unit.

CARGO HANDLING SYSTEMS

Winch

18. A 3000 pound capacity hydraulically operated winch is mounted on the floor in the right forward cabin. Hydraulic power to operate the winch is supplied by the utility hydraulic system. The winch is capable of winching up to 12,000 pounds of cargo and hoisting up to 600 pounds. It is used for air rescue and aerial loading of small general cargo in the hoist mode.

External Cargo

19. The external cargo system consists of three cargo hooks mounted under the aircraft. The center hydraulically-operated hook has a 28,000 pound capacity while the fore and aft electrically-operated hooks have a 20,000 pound capacity. The system is capable of carrying loads individually or simultaneously on all hooks. All hooks have normal, emergency, and manual release modes.

AUXILIARY POWER UNIT (APU)

20. A new model (T62-T-2B) auxiliary power unit, mounted in the aft pylon, is used on the YCH-47D. APU fuel is supplied by the APU boost pump located in the left-hand main fuel cell. The exhaust system consists of a stainless steel duct exiting through the pylon trailing edge. The start and run sequence is operated and monitored by the APU electronic control unit with shutdown occurring if operating limits are exceeded. Built-in test equipment (BITE) provides information relating to the APU failure. Fluid from the hydraulic start accumulator drives the APU-mounted hydraulic pump/motor for starting the APU. A description of APU operation, including the APU start accumulator, hand pump, signal accumulator and APU control box may be found in reference 3, appendix A.

HEATING AND VENTILATION SYSTEM

21. The combustion-type heater and blower is immediately aft of the cockpit bulkhead. Two ducts run forward from the heater defrosting the cockpit transparent areas and heat the cabin. Two ducts run aft feeding into continuous-outlet heat distribution ducts, one on each side of the passenger/cargo compartment under the troop seats. The pilot and copilot windshields are electrically anti-iced, defrosted and defogged. Hot air impingement is used to defrost and defog the Plexiglas side panels and panels below the instrument panel. The center windshield is electrically defogged.

COMMUNICATIONS EQUIPMENT

22. The standard set of communications equipment listed in the operator's manual, (ref 3, app A) was installed in the aircraft with the exception of the Voice Security Equipment (TSEC/KY-28).

FUEL SYSTEM

23. The fuel system is described in the operator's manual, (ref 3, app A). The fuel system furnishes fuel to the engines, heater, and the APU. The system consists of a fuel control panel and two separate fuel systems connected by a crossfeed line. Each fuel system consists of three fuel tanks contained in a pod on each side of the fuselage. The tanks are identified as forward auxiliary, main, and aft auxiliary tanks. Each auxiliary fuel tank contains a fuel booster pump, a booster pump check valve, and a fuel measuring probe. Each main tank contains two fuel booster pumps, two booster pump check valves, three fuel measuring probes, a thermistor which senses low fuel level, and a bypass thermal relief check valve. The fuel tanks are crash-worthy self-sealing tanks with breakaway fittings. The main fuel lines are constructed of self-sealing material.

AIRCRAFT INSTRUMENTS

24. The standard set of instruments listed in the operator's manual (ref 3, app A) was installed on the aircraft.

TEST CONFIGURATION

25. The test aircraft, YCH-47D (S/N 76-8008), photos 2 and 3, with rotor blades removed was installed in the Engine Test Cell of the Climatic Laboratory and supported by jacks located at the forward and aft jack points. The aircraft was then secured to floor anchor joints and four steel blocks (two forward and two aft - each weighing 2-1/2 tons). The cables were fastened to the landing gear and secured laterally to the block located on the opposite side. Arranged in a truss-like manner, the cables damped some of the lateral oscillation inherent to the aircraft during engine operation. Wheel chocks were installed to minimize longitudinal motion. Photos 4 through 7 illustrate the location of the aircraft and associated equipment.

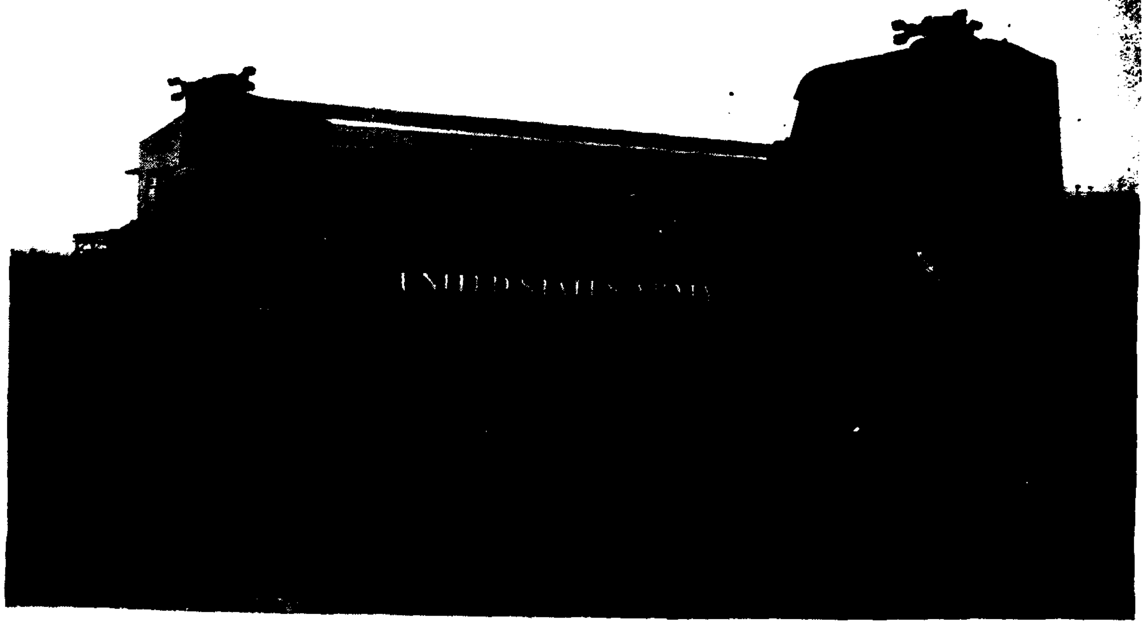


Photo 2. YCH-47D Left Side

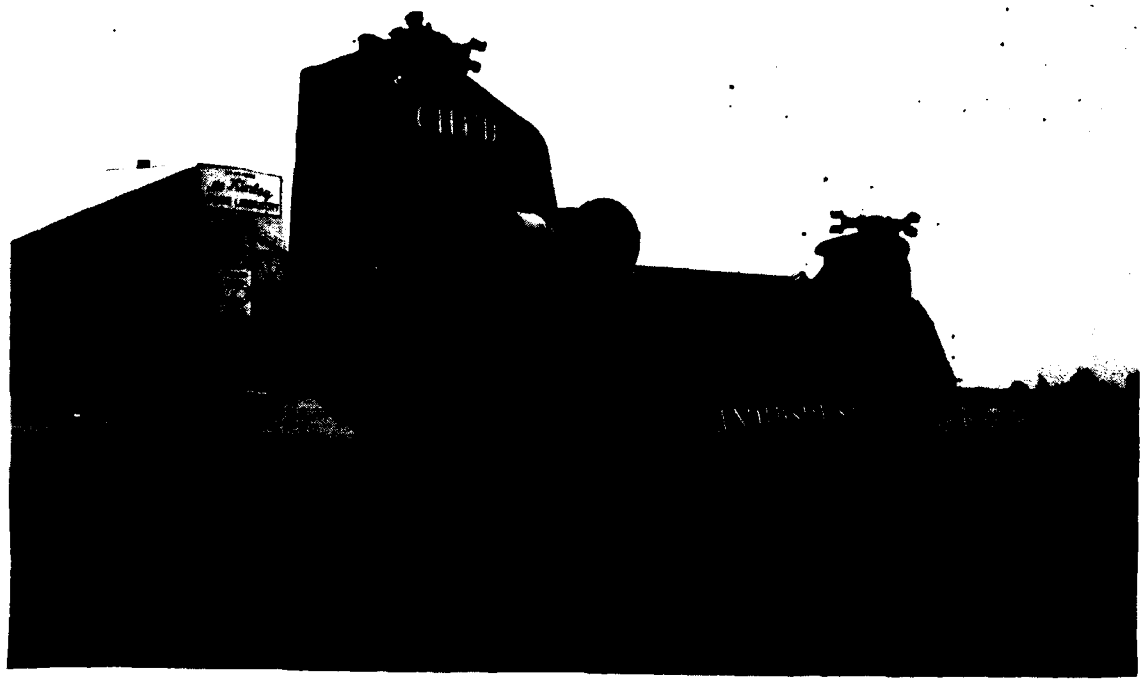


Photo 3. YCH-47D Right Quarter

Photo 4. Exhaust Duct Installation

Photo 5. Tie-down

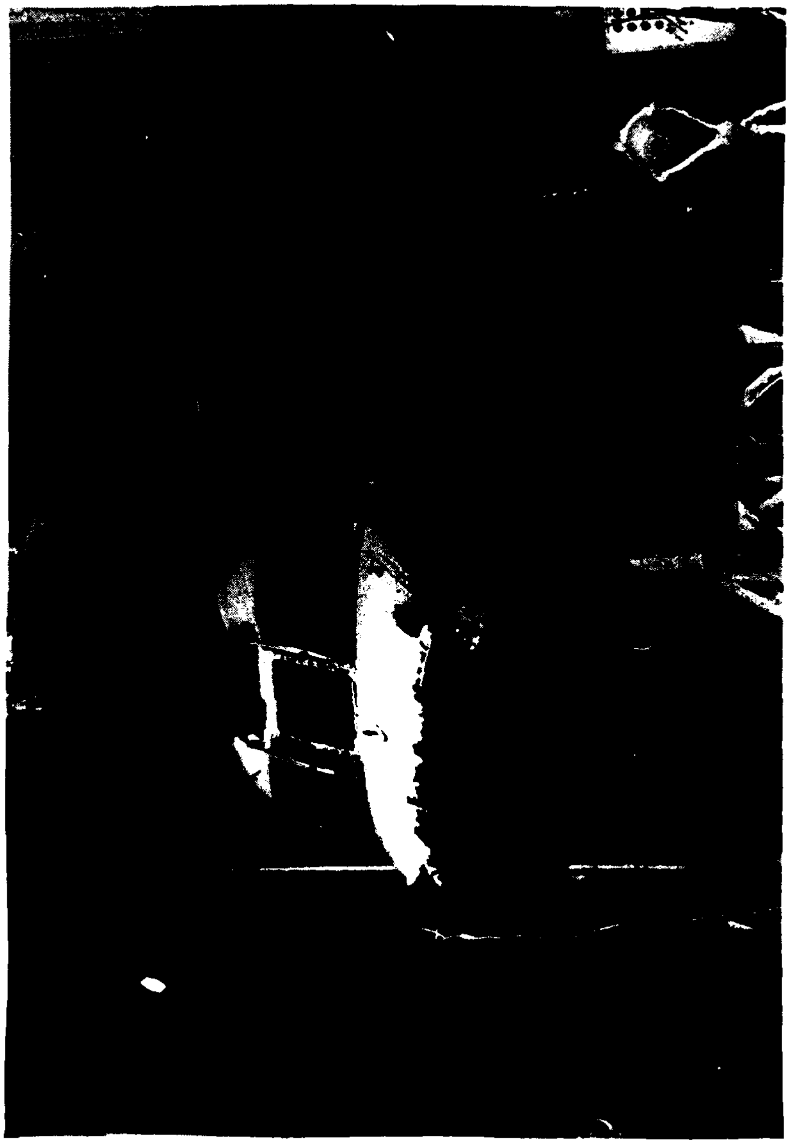


Photo 6. YCH-47D In Test Cell

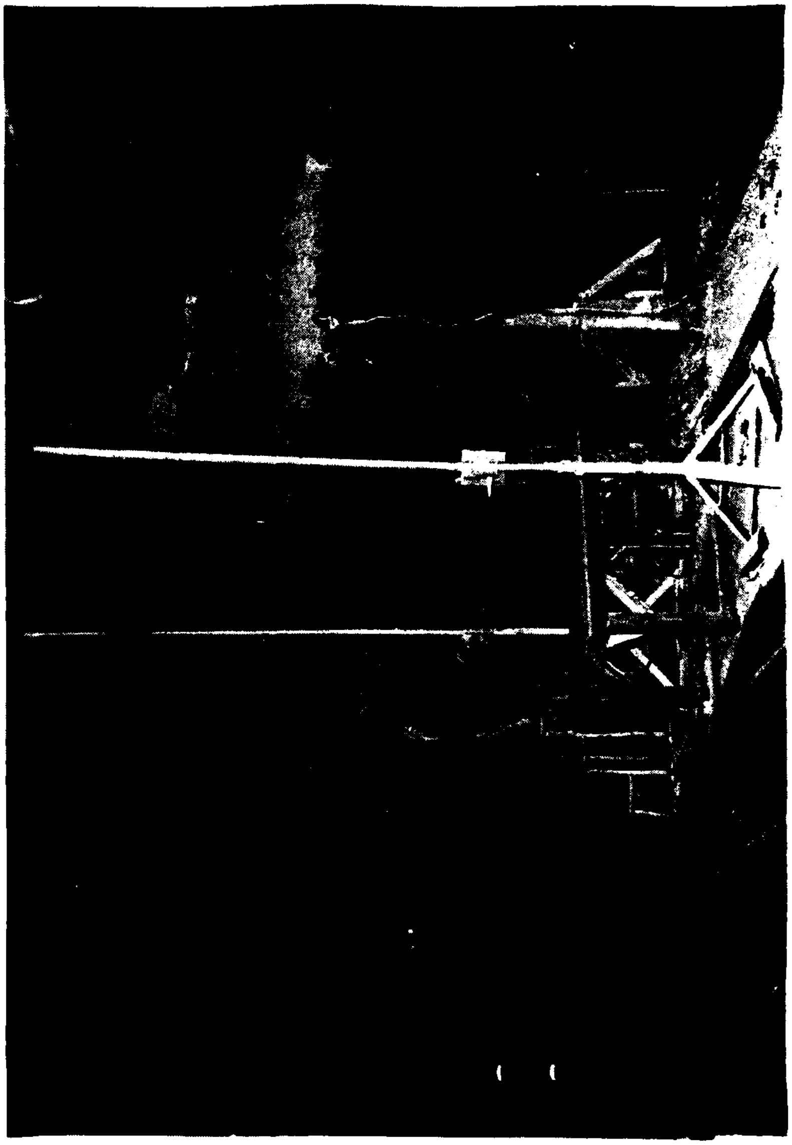


Photo 7. YCH-47D In Test Cell

26. Electrical grounding cables were attached to the aircraft to eliminate static charge build-up and hoses were attached to fuel vents to siphon off fuel vapor during operation at high ambient temperatures.

27. A large scaffold was placed behind the test vehicle to support the engine exhaust and APU exhaust ducts used to vent exhaust gases. Additionally, a duct was run from the heater exhaust port to a suction pump located outside of the chamber. Aircraft and instrumentation electrical ground power cables (28V and 115V) were routed to the aircraft and the instrumentation booth.

28. The instrumentation booth was, in essence, an environmentally-controlled room located in the test chamber in front of the aircraft in which the instrumentation system and electrical load banks were located. BV instrumentation personnel monitored equipment operation from inside the booth during the test. Power sources and data system information were interfaced with the aircraft via cables routed through a metal plate installed in the right forward cabin window to the instrumentation booth. Digitized pulse code modulation (PCM) data were recorded on the tape recorder located in the booth. An additional cable was routed to the Climatic Laboratory Computer Room to provide input signals for a remote cathode-ray tube (CRT) display of selected parameters to personnel in the Test Cell Control Room. These parameters were arranged in matrices pertaining to the APU, transmission and engine operation and were utilized in real time throughout the test runs.

29. A communications link was provided by Armament Division (AD) to allow conversation between the flight crew, control room and instrumentation personnel, exhaust door operator, fire guard, environmental control room (air makeup) and the crew chief during the runs. Scaffolds with safety rails were constructed around the perimeter of the aircraft for easy access to aircraft components. Tables were placed under the cockpit emergency exits to aid in flight crew egress in case of emergency.

APPENDIX C. INSTRUMENTATION

1. The test instrumentation was installed, calibrated and maintained by Boeing Vertol Company (BV). All on-board instrumentation was installed at the BV flight test facility in Wilmington, Delaware. The data recording equipment with associated signal conditioning was installed in an environmentally controlled booth in the test chamber at the Climatic Laboratory. A remote monitor with a digital display of selected parameters was included with the BV instrumentation/data acquisition package; however, the remote monitor was only partially operational about 10 percent of the time and was not used. The Climatic Laboratory maintained test chamber ambient temperature and provided a CRT display with overnight temperature monitoring. The Climatic Laboratory data system was expanded to include the real-time parameters originally intended for the BV remote monitor. All data were recorded on magnetic tape and processed by the Freeman Mathematic Laboratory. Data was prepared in engineering unit tabular form and time histories. The instrumentation package set up in the environmentally controlled booth is shown in photo 1, the load cells used to create an artificial load on the electrical system are shown in photo 2.

2. The following calibrated test instrumentation was installed on the aircraft. The parameters annotated in the display column by CRT (CRT display furnished by the Climatic Laboratory) were displayed during the tests and retained as desired on permanent copy. All parameters were recorded on magnetic tape. The four CRT data presentations utilized on this program are included in table 1.

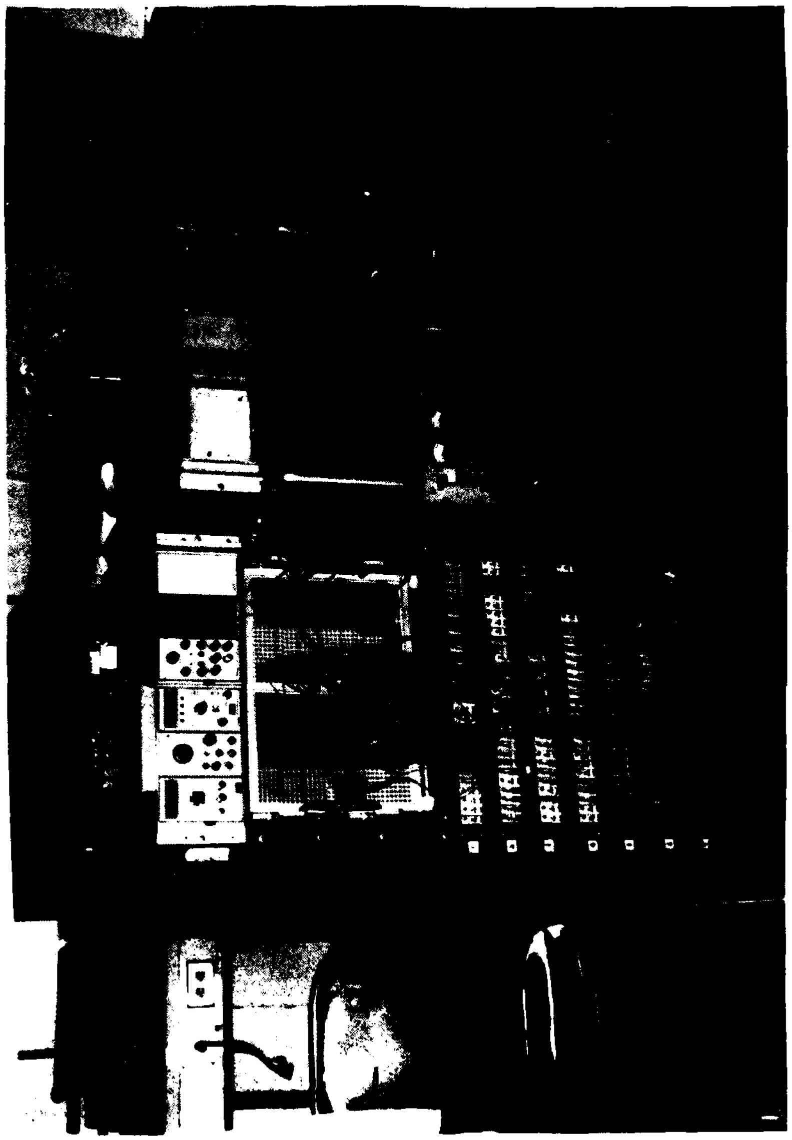


Photo 1. Instrumentation Package

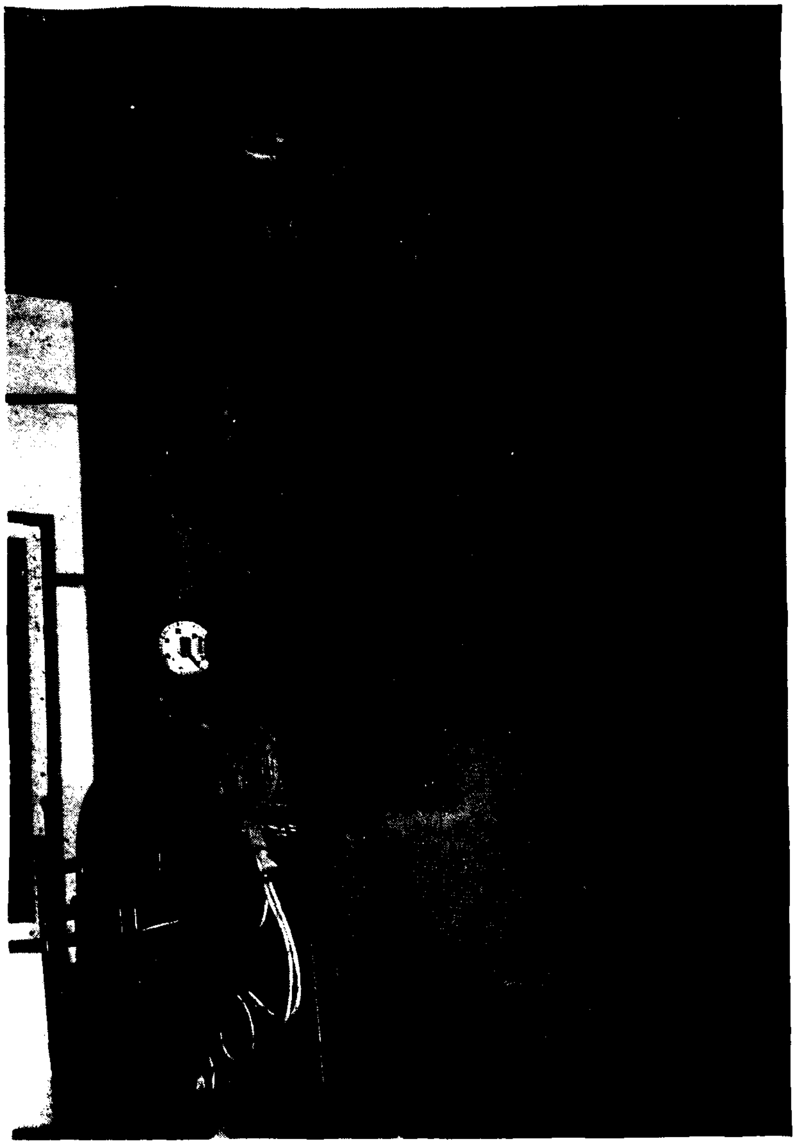


Photo 2. Load Banks

BV No.	Parameter Description	Units	Range	Tape	CRT
	Auxiliary Power Unit				
8419	APU Oil Pump Pressure Out	PSI	0 to 150	X	X
7411	APU Oil Temperature	°C	0 to 150	X	X
9400	APU Pump Case Drain Flow	GPM	0 to 2	X	
9405	APU RPM	Percent	0 to 110	X	X
8403	APU Start Accumulator Pressure Out	PSI	0 to 4K	X	X
8400	APU Start Pump Pressure In	PSI	2K to 4K	X	
9128	Battery Bus Current	AMP	0 to 50	X	
9127	Battery Bus Volts	VDC	0 to 50	X	
7202	Battery Charger Temperature	°C	-55 to 120	X	
7203	Battery Temperature	°C	-55 to 100	X	
7408	Case Drain Temperature, APU Starter Pump	°C	-55 to 150	X	
7412	Exhaust Gas Temperature	°C	-60 to 740	X	X
8420	Inlet Fuel Pressure	PSI	0 to 50	X	
9440	Igniter Amperage Input	AMP	0 to 5	X	
9439	Igniter Voltage Input	VDC	7 to 30	X	
9441	Start Fuel Solenoid	Discrete		X	
8406	Utility Pump Pressure In	PSI	20 to 400	X	
8407	Utility Pump Pressure Out	PSI	2K to 4K	X	
	Engine				
3700	No. 1 Engine N_1 Actuator Position	Degree	0 to 100	X	
3800	No. 2 Engine N_1 Actuator Position	Degree	0 to 100	X	
3701	No. 1 Engine N_2 Actuator Position	Degree	0 to 75	X	
3801	No. 2 Engine N_2 Actuator Position	Degree	0 to 75	X	
3104	No. 1 Engine Condition Lever Position	Gnd/Stop		X	
3105	No. 2 Engine Condition Lever Position	Gnd/Stop		X	
8701	No. 1 Engine Comp Discharge Pressure (Static)	PSIA	0 to 150	X	
8801	No. 2 Engine Comp Discharge Pressure (Static)	PSIA	0 to 150	X	
9700	No. 1 Engine Fuel Flow	GPM	0.5 to 6	X	
9800	No. 2 Engine Fuel Flow	GPM	0.5 to 6	X	
8700	No. 1 Engine Fuel Manifold Pressure	PSIG	0 to 500	X	
8800	No. 2 Engine Fuel Manifold Pressure	PSIG	0 to 500	X	
7700	No. 1 Engine Fuel Temperature	°C	-55 to 60	X	
7800	No. 2 Engine Fuel Temperature	°C	-55 to 60	X	
9703	No. 1 Engine Gas Generator Speed (N_1)	Percent	0 to 110	X	X
9803	No. 2 Engine Gas Generator Speed (N_1)	Percent	0 to 110	X	X
9705	No. 1 Engine Ignition Exciter Volts Input	VDC	0 to 28	X	
9805	No. 2 Engine Ignition Exciter Volts Input	VDC	0 to 28	X	
9706	No. 1 Engine Ignition Exciter Amps Input	AMP	0 to 2.5	X	
9806	No. 2 Engine Ignition Exciter Amps Input	AMP	0 to 2.5	X	
7704	No. 1 Engine Oil Cooler In Temperature	°C	-55 to 170	X	X
7804	No. 2 Engine Oil Cooler In Temperature	°C	-55 to 170	X	X
7705	No. 1 Engine Oil Cooler	°C	-55 to 170	X	
7805	No. 2 Engine Oil Cooler Out Temperature	°C	-55 to 170	X	
8742	No. 1 Engine Oil Pressure	PSI	0 to 110	X	X
8842	No. 2 Engine Oil Pressure	PSI	0 to 110	X	X

BV No.	Parameter Description	Units	Range	Tape	CRT
9704	No. 1 Engine Power Turbine Speed (N_2)	RPM	0 to 17K	X	X
9804	No. 2 Engine Power Turbine Speed (N_2)	RPM	0 to 17K	X	X
9707	No. 1 Engine Start Fuel Solenoid	Discrete		X	
9807	No. 2 Engine Start Fuel Solenoid	Discrete		X	
8200	No. 1 Engine Starter Pressure In	PSI	2K to 4K	X	
8201	No. 1 Engine Starter Pressure Out	PSI	50 to 400	X	
8220	No. 2 Engine Starter Pressure In	PSI	2K to 4K	X	
8221	No. 2 Engine Starter Pressure Out	PSI	50 to 400	X	
7701	No. 1 Engine Turbine Gas Temperature	°C	0 to 940	X	X
7801	No. 2 Engine Turbine Gas Temperature	°C	0 to 940	X	X
	Cabin Temperatures				
7200	Ambient Air Temperature	°C	-55 to 50	X	X
7206	Cabin Station 320, WL 24	°C	-55 to 60	X	
7207	Heater Output Duct	°C	-55 to 60	X	
7108	Pilot's Foot Level	°C	-55 to 60	X	
7106	Pilot's Head Level	°C	-55 to 60	X	
7107	Pilot's Waist Level	°C	-55 to 60	X	
	Electrical				
9436	AC Bus 2 ØA Volts	VAC	100 to 120	X	
9437	AC Bus 2 ØB Volts	VAC	100 to 120	X	
9438	AC Bus 2 ØC Volts	VAC	100 to 120	X	
9415	AC Gen 2 ØA Current	AMP	0 to 70	X	
9416	AC Gen 2 ØB Current	AMP	0 to 70	X	
9417	AC Gen 2 ØC Current	AMP	0 to 70	X	
9418	AC Gen 2 Line Frequency	CPS	320 to 460	X	
7409	AC Gen 2 Case Temperature	°C	-55 to 200	X	
7100	Control Panel/Volt Regulator, Case 1	°C	-55 to 100	X	
7101	Control Panel/Volt Regulator, Case 2	°C	-55 to 100	X	
7204	Left Hand Electrical Compartment Ambient	°C	-55 to 70	X	
9419	Loadbank 1 Kilowatts	KVA	0 to 60		
9420	Loadbank 2 Kilowatts	KVA	0 to 60		
	Flight Controls				
3101	Longitudinal Control Position	Inch	-7 to 8	X	
3100	Lateral Control Position	Inch	-4.2 to 4.2	X	
3103	Thrust Control Position	Inch	0 to 9.15	X	
3102	Directional Control Position	Inch	-3.6 to 3.6	X	
4105	Longitudinal Control Force	Lb	0 to 20	X	
4106	Lateral Control Force	Lb	0 to 20	X	
4107	Directional Control Force	Lb	0 to 35	X	
4108	Collective Control Force	Lb	0 to 20	X	
8301	No. 1 Flight Control Pump Pressure Out	PSI	2K to 4K	X	
8304	No. 1 Power Transfer Unit Out Pressure	PSI	2K to 4K	X	
7301	No. 1 Reservoir/Cooler Temperature In	°C	-55 to 150	X	
8404	No. 1 Aft Actuator Pressure Out	PSI	0 to 400	X	

BV No.	Parameter Description	Units	Range	Tape	CRT
8402	No. 1 Aft Actuator Pressure In	PSI	1500 to 3200	X	
7410	No. 1 Aft Actuator Temperature In	°C	-55 to 105	X	
9402	No. 1 Aft Actuator Flow In	GPM	0 to 4	X	
9303	No. 1 Flight Control Pump Case Drain Pressure	PSI	0 to 400	X	
7302	No. 1 Reservoir/Cooler Temperature Out	°C	-55 to 150	X	
7300	No. 1 Flight Control Case Drain Temperature	°C	-55 to 150	X	
9303	No. 1 Flight Control Pump Case Drain Flow	GPM	0 to 2	X	
8203	PTU Motor Pressure In	PSI	2500 to 3500	X	
8217	SAS Actuator Input Pressure	PSI	0 to 2000	X	
7205	SAS Actuator Input Temperature	°C	37 to 105	X	
3604	Aft Swivel Actuator Position	PCM cts		X	
3504	Forward Swivel Actuator Position	PCM cts		X	
3106	No. 1 Pitch SAS Output Position	PCM cts		X	
9159	No. 1 Pitch SAS Input Position	PCM cts		X	
	Transmission				
7600	Aft Transmission Oil Cooler In Temperature	°C	-55 to 170	X	X
8601	Aft Transmission Oil Pressure	PSI	0 to 100	X	X
7400	Combining Transmission Oil Cooler In	°C	-55 to 170	X	X
8600	Combining Transmission Oil Pressure	PSI	0 to 100	X	X
7703	No. 1 Engine Nosebox Oil Out Temperature	°C	-55 to 170	X	X
7803	No. 2 Engine Nosebox Oil Out Temperature	°C	-55 to 170	X	X
8741	No. 1 Engine Nosebox Oil Pressure	PSI	0 to 100	X	X
8841	No. 2 Engine Nosebox Oil Pressure	PSI	0 to 100	X	X
7506	Forward Transmission Sump Oil Temperature	°C	-55 to 170	X	X
7500	Forward Transmission Oil Cooler In	°C	-55 to 170	X	X
8501	Forward Transmission Oil Pressure	PSI	0 to 400	X	X
	Miscellaneous				
9100	Event Marker	Discrete		X	
9102	Time	Hrs,Min,Sec		X	
——	Record Counter			X	
9603	Rotor Speed (Coarse)	RPM	0 to 280	X	X
7404	Utility Reservoir/Cooler Temperature In	°C	-55 to 150	X	
7405	Utility Reservoir/Cooler Temperature Out	°C	-55 to 150	X	
9404	Utility Pump Outlet Flow	GPM	0 to 17	X	

Table 1. Real Time/CRT Parameters

Overnight Temperatures

Time	Temperature
hrs, min, sec	°F

APU Parameters

	Time	Oil Press	Oil Temp	EGT	RPM	Start Press	Batt Volt	Batt Amp	Outside Air Temp
(a)	hrs, min, sec	PSI	°C	°C	percent	PSI	VDC	AMP	°F
(b)		0+150	-55+150	-60 +740	0 +112	0 +4K	0 +50	0 +50	-70 +130
(c)		15-40	0+140	740	98 - 101		24 - 32	0 +10	

Transmission Parameters

	Time	Fwd Oil Press	Comb Oil Press	Aft Oil Press	Fwd Oil Cooler In Temp	Comb Oil Cooler In Temp	Fwd Sump Oil Temp	Aft Oil Cooler In Temp	No. 1 Nose Box Oil Press	No. 2 Nose Box Oil Press	No. 1 Nose Box Oil Temp	No. 2 Nose Box Oil Temp
(a)	hrs, min, sec	PSI	PSI	PSI	°C	°C	°C	°C	PSI	PSI	°C	°C
(b)		0+250	0 +100	0 +100	-55 +170	-55 +170	-57 +57	-55 +170	0 +100	0 +100	-55 +170	-55 +170
(c)		20-90	20 - 90	20 - 90	140	140	-55 +150	140	20 - 90	20 - 90	140	140

Engine Parameters

	Time	No. 1 Oil Press	No. 2 Oil Press	No. 1 Oil Temp	No. 2 Oil Temp	No. 1 Power Turbine Inlet Temp	No. 2 Power Turbine Inlet Temp	No. 1 N_1	No. 2 N_1	No. 1 N_2	No. 2 N_2	Rotor RPM
(a)	hrs, min, sec	PSI	PSI	°C	°C	°C	°C	pct rpm	pct rpm	rpm	rpm	rpm
(b)		0+150	0+150	-55 +170	-55 +170	0 +940	0 +940	0 +110	0 +110	0 +16K	0 +16K	0 +280
(c)		35-90	35-90	140	140	400 - 780	400 - 780	60 - 99.5	60 - 99.5	60 - 99.5	60 - 99.5	216 - 244

(a) Units
(b) Instrument range
(c) Operating range

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

1. The YCH-47D Climatic Laboratory Survey was conducted at the McKinley Climatic Laboratory in Eglin Air Force Base, Florida. The aircraft was installed in the engine test facility, placed on jacks and restrained from movement, and tested without rotor blades. Each test sequence consisted of an aircraft and instrumentation pre-check, the test following a standard test procedure, and post-check of both the aircraft and instrumentation system. The aircraft pre-check utilized an inspection guide prepared by USAAEFA for the YCH-47D Climatic Test. This inspection guide was based on the normal 10 hour inspection requirement prepared by BV and modified to accommodate a CH-47 without blades in a cold box. The aircraft battery was removed at temperatures below 0° F for overnight storage. The aircraft fuel temperature was checked prior to each test to assure adequate cold/heat soak time. All accumulator pressures were checked prior to each test and compared to the readings taken following the previous test. A record of the number of hand pump strokes required to bring the APU start accumulator up to normal operating pressure versus ambient temperature was maintained. All pre-test oil levels were noted and compared to post-test indications. A record of overnight test cell temperature was checked to assure desired test environment.

2. Data from the initial tests at 70° F, during the first week of testing were to be used to establish a baseline. This baseline would then be the norm to which the data from other test temperatures would be compared. The instrumentation problems discussed later degraded the effort to establish a baseline. For comparison purposes all data presented at 70° F temperature, in this report, was acquired subsequent to the -65° F testing. The comparison of the usable APU, engine and transmission data of run 3 (70° F) with post -65° F testing data indicate no change due to low temperature testing.

3. The instrumentation system, onboard parameters and signal conditioning and recording equipment were checked prior to each test by BV personnel using BV instrumentation procedures. A record of the BV pre-run calibration cycle "step 4, step 5 functions" was made before and after each test. Each parameter was checked to determine that it was functional and within tolerance by this calibration cycle. This record was used to assist in maintaining and troubleshooting the instrumentation system.

4. A standard test procedure, included in this section, was utilized for each test. This procedure followed normal US Army aircraft and specifically CH-47 cold/hot weather operating procedures. At each temperature one start/test was accomplished utilizing a "tactical emergency" procedure in an effort to arrive at take-off time and conditions as soon as practical. The aircraft was observed during testing by the test director from a vantage point through a window opposite the cockpit. Each item in the procedure was announced by the test pilot and acknowledged by the test director as required. Page 63 through 72 present the standard test procedure followed during this climatic laboratory evaluation.

5. The aircraft post-test inspection was performed in accordance with the pre-test "10 hour" inspection. All fluid levels were checked immediately after each test and the results are included in appendix F. The flight control hydraulic actuator impending jam indicators were checked after power transfer unit (PTU) activation and at the end of each test.

6. Data were recorded on magnetic tape and processed at the Freeman Mathematic Laboratory. Simultaneously 0-5 volt signals for selected parameters

were directed to the Climatic Laboratory computer room to be monitored in real time. A CRT remote monitor and a CRT control keyboard were utilized in the control room by the test director for real time data monitoring. A table of the real time/CRT parameters is presented in appendix C. Manually recorded data were utilized to corrolate test activity and select appropriate time sequences for computer generated data.

7. The APU was started and generators and PTUs turned ON. The electric and hydraulic evaluation was initiated with the APU start. The transmission evaluation was conducted during the time frame corresponding to the engine start and run characteristics. The cabin temperature evaluation was centered around the heater operation and compares heater output temperature with various cabin location temperatures. All systems, radios, hoist, hooks, brakes, ramp, power steering, etc., were qualitatively checked for operation at all temperatures.

8. During each test the electrical system was artificially loaded by instrumentation load cells and the No. 1 main generator failure simulated. This procedure was performed at each temperature to determine any apparent effect on the electrical system and the operating generators ability to accept the entire load.

9. The flight control system was qualitatively evaluated at all temperatures for control forces, total travel, and the ability of the PTU to maintain hydraulic pressure during control travel checks. A flight control system amplitude and frequency response test was conducted following engine start. Normal checklist procedures were used to check the flight controls, and during APU operations control forces were evaluated. If the control forces at cold temperatures were excessive to the point that the aircraft could not, qualitatively, be flown, control inputs were made to exercise the system. All controls were displaced throughout their full range to increase the hydraulic oil temperature and reduce the friction in the viscous dampers in the roll and yaw axis. Each flight boost system was checked independently for binding and travel. Longitudinal and lateral control forces were evaluated using a handheld force gage. Another flight control travel check was made after engine start and with the transmission mounted hydraulic flight control pumps on line. The amplitude and frequency response check was made through a test plug on the No. 1 AFCS control box. Shorting wires in the plug produced a hardover condition in the roll and yaw axis. The cyclic, thrust and pedals were rigged to position the swiveling actuator sensors at mid band. A direct current voltage from a signal generator was input through the No. 1 AFCS control box to the pitch ILCA once the No. 1 AFCS system was selected by the pilot. An amplitude sweep was conducted at a frequency of 0.32 Hz and varying the amplitude in four steps. The signal generator was set at a level that would displace the pitch ILCA ±0.02, 0.04, 0.06 and 0.125 inches respectively and approximately three cycles at each amplitude were recorded. Total system hysterisis was displayed in plots of the generator voltage input versus: pitch ILCA, forward swiveling actuator, and aft swiveling actuator output in inches. While recording data at the last amplitude of ±0.125 inches a phase analysis was made to determine the starting frequency for the response test. The phase angle was determined by nulling the Lissajous pattern on a four trace oscilloscope. If the phase lag of the ILCA to aft actuator was less than 30 degrees a starting frequency of 0.56 Hz was used, otherwise the starting frequency was 0.10 Hz. The signal generator amplitude was set to produce a pitch ILCA output of ±0.125 inch for all frequency response testing. Two methods were used to conduct the test. One utilized selecting eight discrete frequencies and recording at least 5 cycles at each frequency. The second method involved sweeping through the complete band

starting at 0.10 Hz and, at a slow rate, increasing the frequency to 40 Hz so as to cover the spectrum in 2 minutes. The frequency response data were presented in a time history, Bode, and phase plots. The Bode data is a gain plot in decibels (db): Gain (db) = $20 \log_{10}$ (output/input). The PCM sampling rate limited frequency response analysis to 22 Hz. The computations were accomplished using a Fast Fourier Transform (FFT) routine. The AFCS was checked by displacing the longitudinal cyclic approximately 1 inch and activating the No. 1 and 2 AFCS. The differential airspeed hold (DASH) programmed to the new stick position, nulled the system error, and extinguishing AFCS caution light on each system. The flight control system test procedure followed during this evaluation is included in this section on pages 71 to 72.

10. The instrumentation system was installed and maintained by BV. The instrumentation package arrived at Eglin Air Force Base aboard the test aircraft. It was installed in an environmentally controlled and maintained booth in the test chamber in front of the aircraft. There were a number of problems with the instrumentation support on this program. The first and major problem was that the system as configured for the hangar testing had not been powered prior to its arrival at Eglin Air Force Base. Despite assurances that the system was checked out and operational, it was turned on for the first time on 5 September 1980 at the Climatic Laboratory in Eglin Air Force Base. There simply was not enough time to check out the system after its arrival at the test site.

11. The remote monitor was only partially operational about 10 percent of the time and was not used. Data processed by the hangar computer and presented on the CRT was utilized.

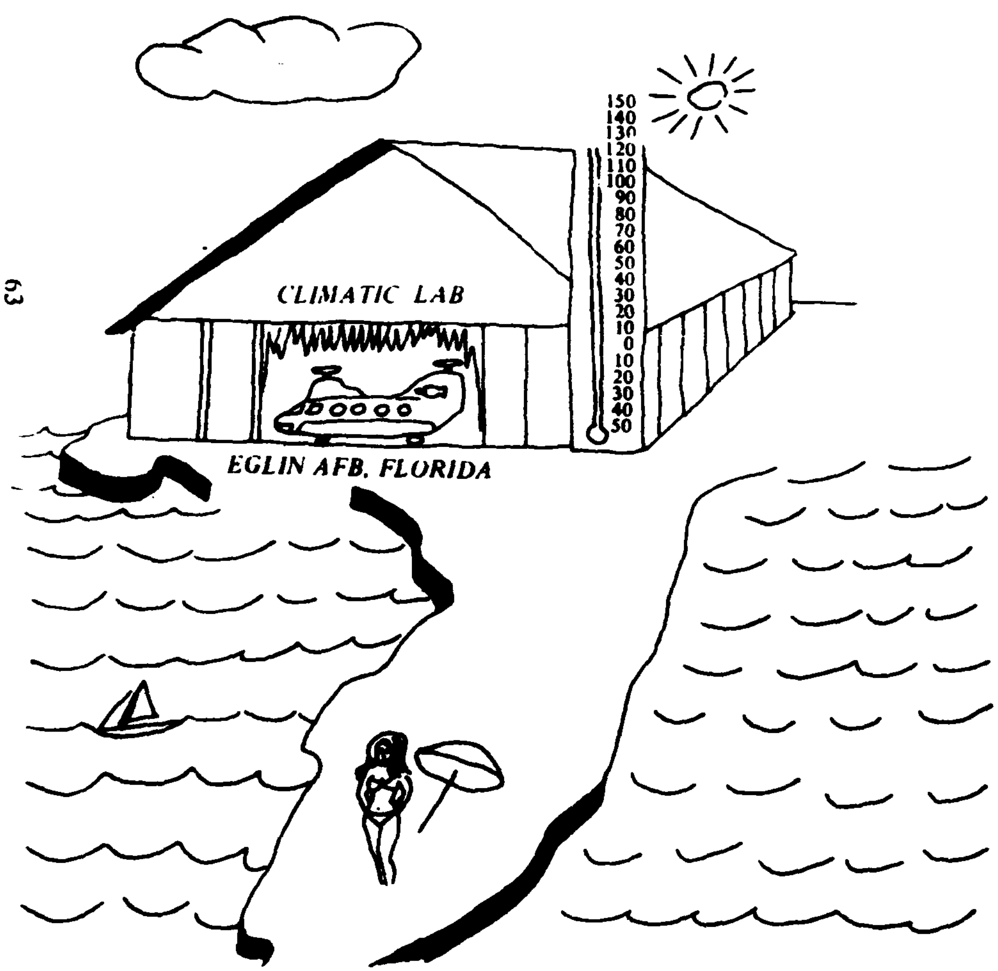
12. The data from the control force parameters were unreliable and could not be correlated with any other control characteristics data. The only usable control force data was taken by the test pilot at 70° F and -50° F with a manual hand held gage. This hand held data at 70° F compared favorably with data from the YCH-47D PAE, USAAEFA Project No. 79-06.

13. Initially there was insufficient time allocated to assemble and check out the instrumentation system prior to the test. Greater than 25 percent of the data were unusable from the first two runs. This affected the program in that the degraded performance of the instrumentation system compromised establishing the 70° F data baseline and reduced the effectiveness of the test. At the end of the program, specifically the last four runs, only 4 percent of the data was unsatisfactory. With adequate time prior to the start of testing the system would have had a chance to meet the instrumentation system requirements. This additionally affected the data processing, since errors and unknowns in the instrumentation required numerous and time-consuming repeats of the data reduction process.

Data Recorded By ____________________

YCH-47D CLIMATIC LABORATORY EVALUATION
USAAEFA PROJECT NO. 79-13

TEST PROCEDURE



Temperature ____________ Date ____________

Profile ____________ Run No. ____________

Start Time ____________

Run Duration ____________

	NOTES - RANGES	REMARKS	GMT TIME

I. PREFLIGHT INSPECTION

1. N_1 Free
2. Engine Screens
3. Fuel Temp
4. Accum. Pressure-Gage/ CRT
   Number of Strokes Required
5. Oil Level Check
6. Access/Inspection Doors
7. Overnight Temp - Hard Copy
8. Remote Console - ON
9. Menus - Quick Look

II. PRETEST

1. External Power OFF, Battery Connected
2. Helmets
3. Battery - ON
4. "COMM Check"
   a. Flight Engineer
   b. Fire Guard
   c. Exhaust Door Operator
   d. Air Makeup
   e. Instrumentation Booth
   f. Data Room
   g. Test Advisor
   h. Test Director
   i. Project Officer
5. Seat Belt and Harness
6. No. 1 and 2 PDP - Check
7. Overhead switches, controls and cockpit lights - as required
8. FIRE EXT AGENT SWITCH - Neutral
9. FIRE CONTROL HANDLES - IN
10. System Instruments - Check
11. Pressure Altitude ______ : :
12. XMSN OIL PRESS - SCAN
13. XMSN OIL TEMP - SCAN
14. MASTER CAUTION LT - TEST
15. AFCS SYSTEM SEL - OFF
16. NORM ENG TRIM - ON
17. Avionics - OFF and Set
18. Clock - Set : :
19. Tape Recorder - ON
20. "This is run ___ on aircraft 001, ___ hours, ___ Sept - Oct, 1980 ___ °F, Climatic Hangar, Eglin AFB."
21. "STEP 4" (Inst Preflight Calibration) : :
22. "STEP 5" (Inst Preflight Calibration) : :

	NOTES - RANGES	REMARKS	GMT TIME
III. APU START AND RUN			
1. Exhaust Door - Open			
2. Troop Alarm - Ring			
3. Fire Guard - Posted to Start APU			
4. APU - Run 3 sec. Then Start	HYD ACC PRESS: 3000 psi MIN OIL PRESS: 40 psi MAX, 6 psi MIN Ng: 112 pct MAX OIL TEMP: 140° C MAX EGT: 740° C MAX		: :
5. APU Caution Light - ON			
6. UTIL HYD SYS - caution light - OUT	HYD PRESS: 2500 - 3500 psi TEMP: 107° C MAX		
7. APU GEN - ON	BATTERY VOLTAGE: 24 increases 28 - 29		: :
8. HYDRAULIC OIL TEMP	Flt #1 _____ Flt #2 _____ Utility _____		
9. RECTS OFF: caution - OUT			
10. PTU No. 1 - ON			: :
11. FLT CONTR No. 1 caution - OUT	HYD PRESS: 2500 - 3200 psi		
12. PTU No. 2 - ON			
13. FLT CONTR No. 2 caution - OUT			
14. Avionics - ON			
15. CRUISE GUIDE - Test			
16. Radar Altimeter - ON - Test			
17. FIRE DETECTOR - Test			
18. AFCS - No. 1, BOTH No. 2, OFF			
19. Flight Control and Hydraulics			
*a. FLT CONTR No. 1 ON CONTROL SWEEP			: :
*b. FLT CONTR No. 2 ON CONTROL SWEEP			: :
c. FLT CONTR - BOTH (Control Sweep abbreviated run)			
d. CONTROL FORCES Fwd, Aft, Left, Right, Left, Right, Up, Down.		Start End	: : : :
20. XMSN Oil Temp			

	Cockpit	Remote
Rt		
Lft		
Mix		
Aft		
Fwd		

*Delete for abbreviated run

	NOTES - RANGES	REMARKS	GMT TIME
III. APU START AND RUN Cont.			
21. Hydraulic Oil	Cockpit Press / Cabin Temp Flt 1 ____ ____ Flt 2 ____ ____ Util ____ ____		
IV. PRE-ENGINE START			
1. ENGINE BEEP TRIM - DECR 8 sec.			
2. FIRE GUARD - Posted to Start Fuel Boost Pumps			
3. Clearance to Proceed - Test Director			
4. ENG No. ___ FUEL PUMP - ON			
5. LEFT FUEL PRESS caution - OUT			
6. CROSS FEED FUEL VALVE - OPEN			
7. RIGHT FUEL PRESS caution - OUT			
8. Anti-collision light - ON			
9. Air Makeup - Starting Engines			
****V. ENGINE START**			
1. FIREGUARD POSTED TO START No. ___ ENG			
2. START SWITCH - MOTOR			: :
3. ECL - GROUND 10 pecent			: :
4. N_2 Turning - Check		____	
5. Start Switch - Start to 340° C PTIT			: :
6. Start Switch - OFF N_1 50 percent	ENG OIL TEMP: 140° C MAX		
7. N_1 = 60 - 63 percent	TRANS OIL TEMP: 140° C MAX		: :
8. Eng Oil Pressure	ENG OIL PRESS (PSI) 20 MIN 110 MAX		
9. Trans Oil Pressure	TRANS OIL PRESS: increase to 7 MIN 90 psi MAX		
VI. ENGINE RUN			
1. FIREGUARD POSTED No. 1 and 2 - FLIGHT	N_1 : 107 pct MAX		
2. ECL - FLIGHT	N_2 : 107 - 111 pct (241 - 250 rpm) 12 sec. 112 MAX ENG OIL PRESS: 110 psi MAX TRANS OIL PRESS: 90 psi MAX		: :

**Repeat for 2nd engine

NOTES - RANGES **REMARKS** **GMT TIME**

VI. ENGINE RUN Cont.

3. ENGINE BEEP TRIM to 225 ROTOR RPM
4. Fluid Drain and Pressure Line Leakage
5. No. 1 and No. 2 GEN - ON: Gen - OFF caution OUT
6. APU GEN - OFF
7. No. 1 and No. 2 PTU - OFF
8. APU - Stop — ___:___:___
9. No. 1 GEN - OFF - ON
10. No. 2 GEN - OFF - ON
11. ENG ANTI-ICE - ON Below +4° C

	N_1	PTIT Before	PTIT After
No. 1	____	____	____
No. 2	____	____	____

12. FUEL PUMPS - Check
13. ALL FUEL PUMPS - ON Crossfeed - OPEN
14. XMSN OIL TEMP and PRESS - Check — ___:___:___

XMSN OIL	Press	Temp
Right	____	____
Left	____	____
Mix	____	____
Aft	____	____
Fwd	____	____

15. Emergency Engine trim - Check
16. Master Caution Panel Check
17. Power Steering Check
18. Brake - Set and Release
19. Cargo Hook Arm and Release
20. Ramp - Up
21. Cabin Door Closed
22. Heater - ON

VII. FLIGHT CONTROL AND HYDRAULICS

*1. FLT CONTR No. 1 ON - CONTROL SWEEP — ___:___:___
*2. FLT CONTR No. 2 ON - CONTROL SWEEP
3. FLT CONTR - BOTH (Control Sweep on Abbreviated Run)
4. AFCS No. 1 J2 Plug IN
5. AFCS - No. 1 Rig Check

*Delete for abbreviated run

		NOTES - RANGES	REMARKS	GMT TIME

VII. FLIGHT CONTROL AND HYDRAULICS Cont.

		NOTES - RANGES	REMARKS	GMT TIME
6.	Amplitude Sweep:	Freq: 0.32 Hz Amp: ±0.020, ±0.040, ±0.060, ±0.125 If phase lag is less than 30°, start freq sweep at 0.56 Hz to 20 Hz. Otherwise start at 0.10 to 5.6 Hz. PHASE: ______		: :
7.	Freq Sweep:	Amp: ±0.125		
		Freq: 0.56 Hz 0.10 Hz		: :
		1.0 0.18		: :
		1.8 0.32		: :
		3.2 0.56		: :
		5.6 1.0		: :
		10 1.8		: :
		Sweep up 3.2		: :
		5.6		: :
8.	AFCS No. 1 J2 Plug OUT			
9.	AFCS - BOTH			
10.	Pitch Input Fwd 50 pct			
11.	AFCS - OFF			
12.	Pitch Input Aft 40 pct			
13.	AFCS - BOTH			
14.	AFCS - OFF			

VIII. MISCELLANEOUS

		NOTES - RANGES	REMARKS	GMT TIME
1.	LOAD BANK No. 1 - ON			
2.	INCREASE LOAD 5 KVA Steps to 15 KVA			
3.	LOAD BANK No. 2 - ON			
4.	INCREASE LOAD 5 KVA Steps to 15 KVA Total: 30 KVA			
5.	GEN No. 1 - OFF Then ON			: :
6.	LOAD BANKS No. 1 and No. 2 - OFF			
7.	RADIO CHECK			
8.	Hoist Operational Check			
9.	Hydraulic Cooler Fan CB OUT - Above 65° C			
10.	Hydraulic Temp Check			
11.	Hydraulic Cooler Fan CB - IN			
12.	CYCLIC TRIM - Cycle	Retract Time: Fwd ____ sec. Aft ____ sec.		

IX. ENGINE SHUT DOWN

	NOTES - RANGES	REMARKS	GMT TIME
1. Ready for Engine Shutdown - Test Director	Dispatch Exhaust Duct Operator		
2. Heater Switches - OFF			
3. ANTI-ICE - OFF			
4. Flight Controls Neutral			
5. Ramp - Down			
6. FIRE GUARD POSTED TO START APU			___:___:___
7. APU - START			
8. APU Caution Light - ON			
9. UTIL HYD SYS Caution Light - Out			
10. APU GEN - ON			
11. GEN No. 1 and No. 2 - OFF			
12. PTU No. 1 and No. 2 - ON			
13. Air Makeup - Check			
14. FIRE GUARD POSTED No. 1 and No. 2 ENGINE TO GROUND			
15. ECL - Ground for 1 minute			___:___:___
16. FIRE GUARD POSTED No. ____ ENGINE TO STOP			
17. No. ___ ECL - STOP	PTIT: Above 350° C motor engine to 260° C		___:___:___
18. FIRE GUARD POSTED No. ____ ENGINE TO STOP			
19. No. ____ ECL - STOP			___:___:___
20. FUEL PUMP - OFF Crossfeed - Closed			
21. Fuel Quantity		pounds:______	
22. Avionics - OFF			
23. Maintenance Panel Check			
24. Flight Control Rig - Check			
25. External Power IN, ON			
26. PTU No. 1 and No. 2 - OFF			
27. Anti-collision Light - OFF			
28. APU GEN - OFF			
29. APU Switch - OFF			___:___:___
30. Post Flight Calibration			
"STEP 4"			___:___:___
"STEP 5"			___:___:___
31. Exhaust Duct - Closed			
32. BATT Switch - OFF			
33. Tape Recorder - OFF			___:___:___
34. END OF TEST			
35. Schedule Post-test Briefing			

NOTES - RANGES **REMARKS** **GMT TIME**

X. POST-FLIGHT INSPECTION

1. Post-flight Inspection - Modified Ten Hour Inspection Requirement (THIR)
2. Call Menu #16 - Overnight Temperature
3. Schedule Following Run

YCH-47D FLIGHT CONTROL FREQUENCY RESPONSE TESTING
Climatic Laboratory Evaluation

Purpose

To perform a flight control frequency response evaluation on the flight control system of the YCH-47D over a range of ambient temperatures.

Configuration

Flight Control Hydraulics No. 1 and No. 2
AFCS No. 1 Selected
Test set-up as indicated in figure 1

Pitch - Active
Roll and Yaw - Inactive

Instrumentation

Signal Generator Output
No. 1 Pitch ILCA Position
Forward Upper Boost Swiveling Actuator Output
Aft Upper Boost Swiveling Actuator Output

Equipment

Signal Generator
ILCA Control Box
Oscilloscope - Four Trace
Voltmeter

***Test Technique**

1. Exercise flight controls with both hydraulic systems

2. Check each flight boost system

3. Amplitude Sweep
   Frequency 0.32 Hz
   ILCA position amplitudes 0.020,0.040,0.060,0.125 inches.

4. Discrete Frequency Sweep
   ILCA Position Amplitude 0.125 in.
   Frequency Sweeps
   - 0.1 to .56
   - .56 to 1.0
   - 1.0 to 5.6
   - 5.6 to 10.0
   - 10.0 to >22

Perform test with engines running and flight control system No. 1 and No. 2 operating.

*Repeat for each temperature

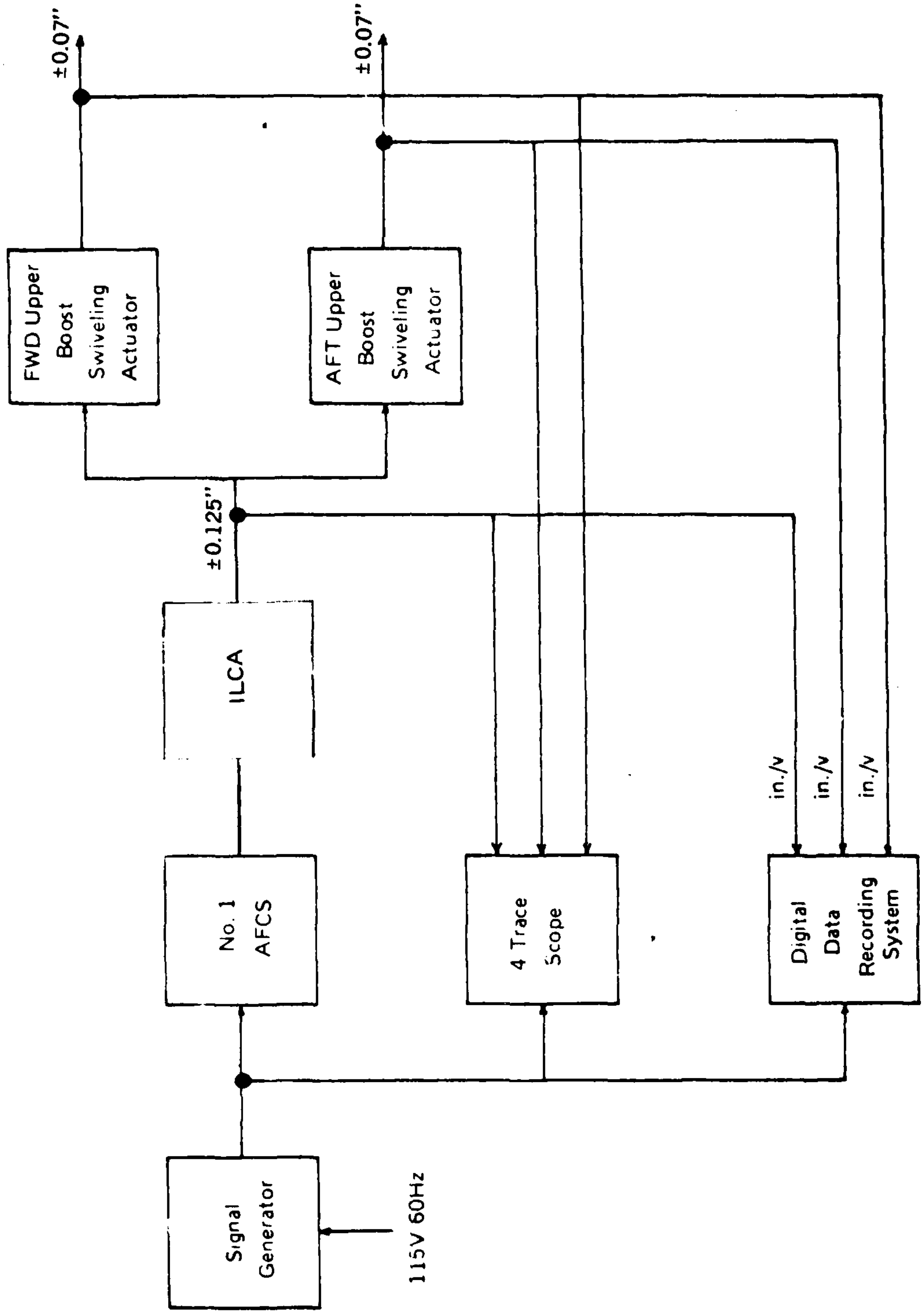

±0.07"
±0.07"
FWD Upper Boost Swiveling Actuator
AFT Upper Boost Swiveling Actuator
±0.125"
ILCA
No. 1 AFCS
4 Trace Scope
Digital Data Recording System
in./v
in./v
in./v
Signal Generator
115V 60Hz

Figure 1

APPENDIX E. TEST DATA

INDEX

FIGURE 1
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES:
1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. START ACCOMPLISHED SUBSEQUENT TO -65° F TESTING

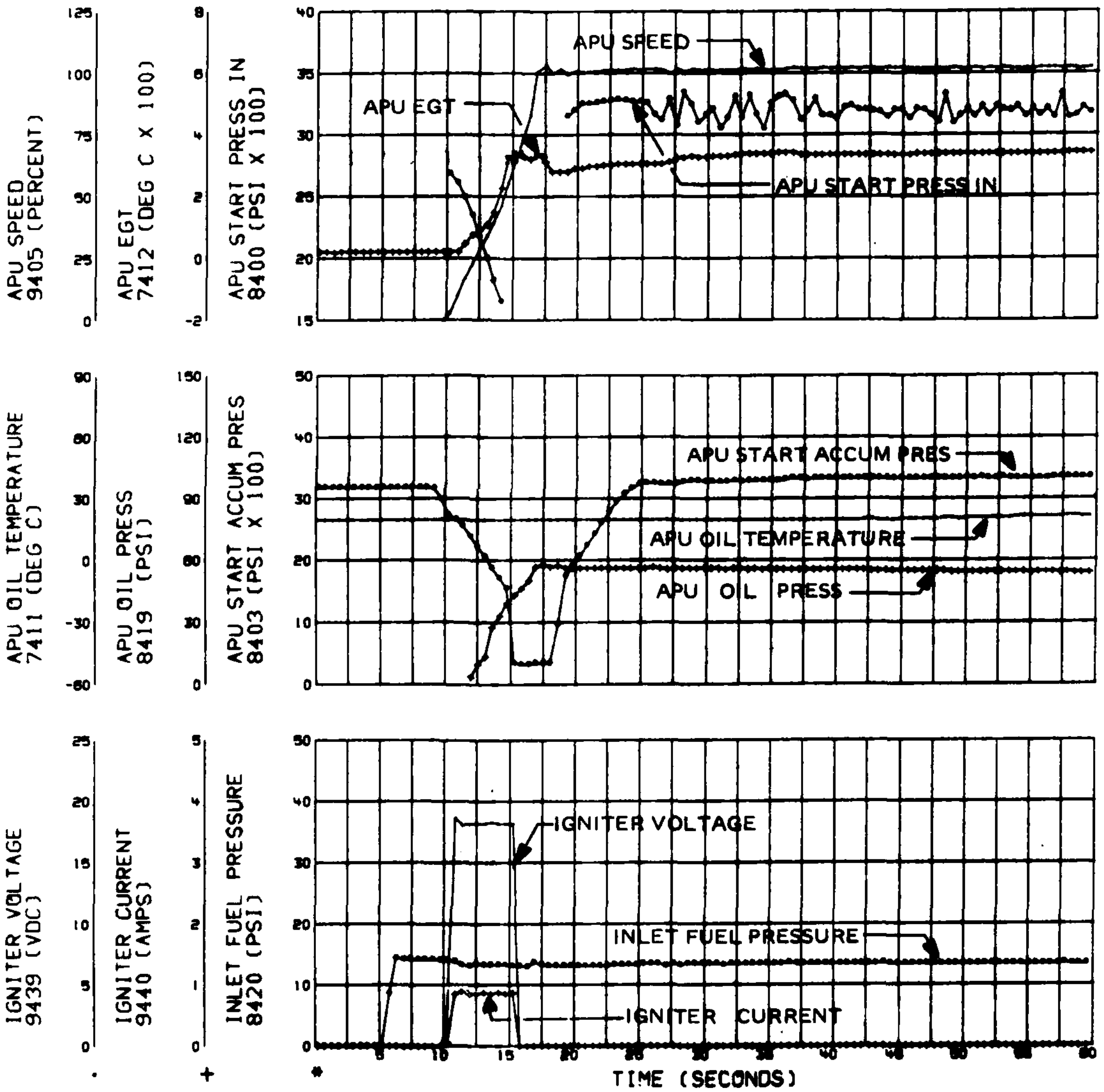


FIGURE 2

APU START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T62-T-2B APU S/N 377312

CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES: 1. APU SERVICED WITH MIL-L-23699 OIL

2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

3. IGNITER CURRENT AND INLET FUEL PRESSURE INSTRUMENTATION INOPERATIVE

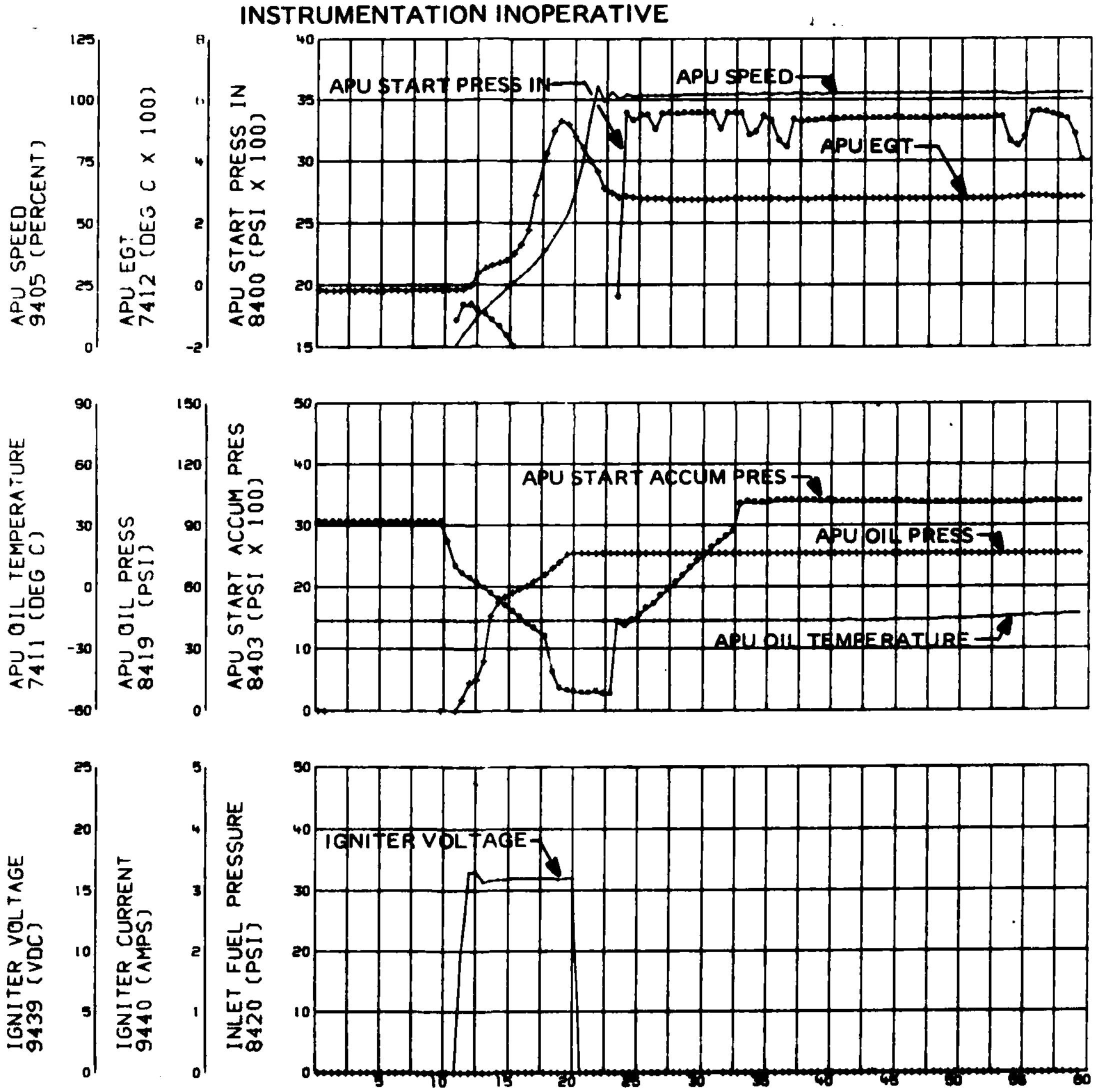


FIGURE 3

APU START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T62-T-2B APU S/N 377312

CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES:
1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. START SELF-ABORTED AT 685° C EGT
4. IGNITER CURRENT INSTRUMENTATION INOPERATIVE

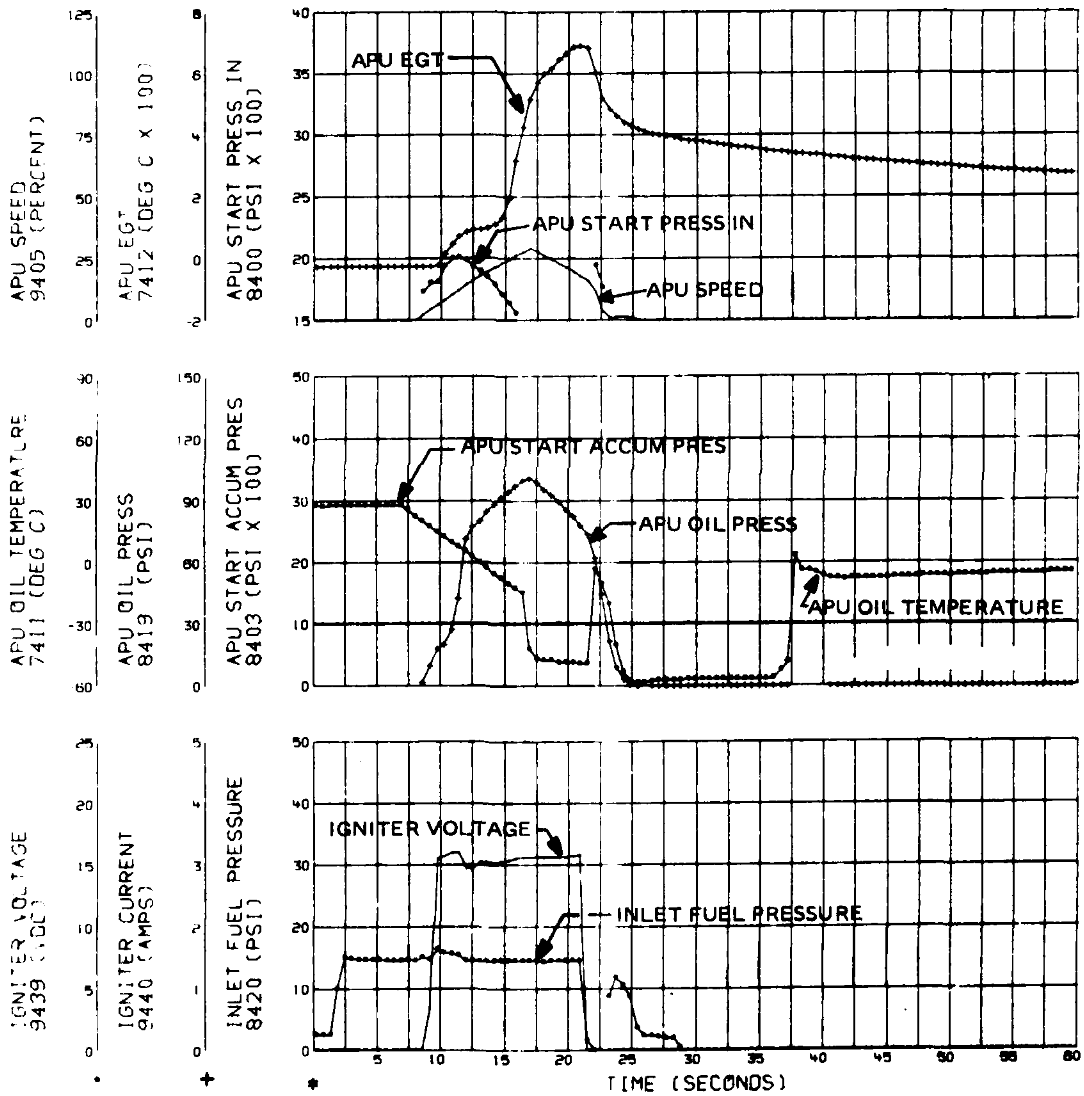


FIGURE 4
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES:
1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. SUCCESSFUL START 10 MINUTES AFTER FIRST START ATTEMPT (NO HEAT APPLIED)
4. IGNITER CURRENT INSTRUMENTATION INOPERATIVE
5. APU START PRESSURE INOPERATIVE

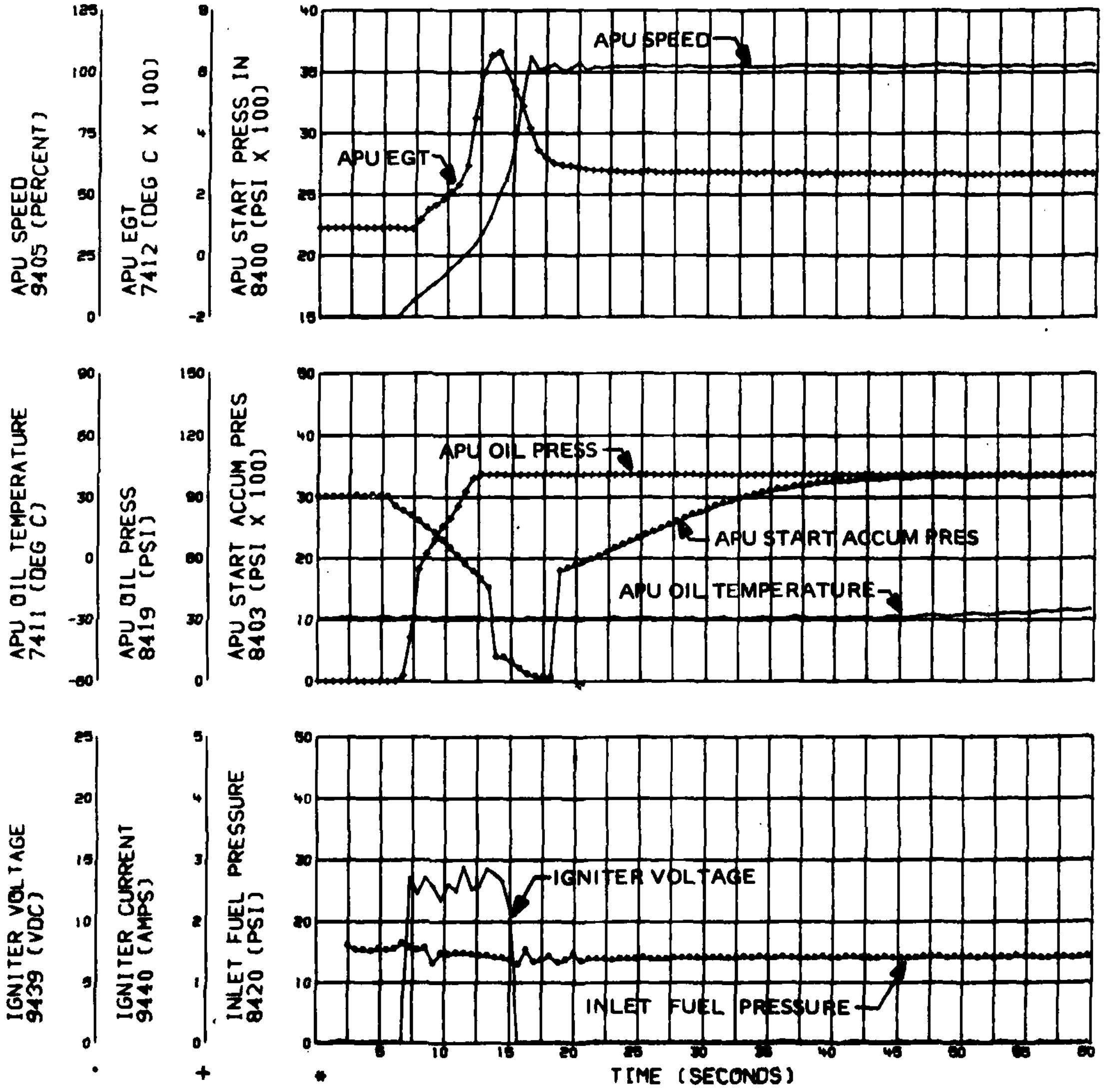


FIGURE 5
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. SUCCESSFUL START ON FIRST ATTEMPT
4. IGNITER CURRENT INSTRUMENTATION INOPERATIVE

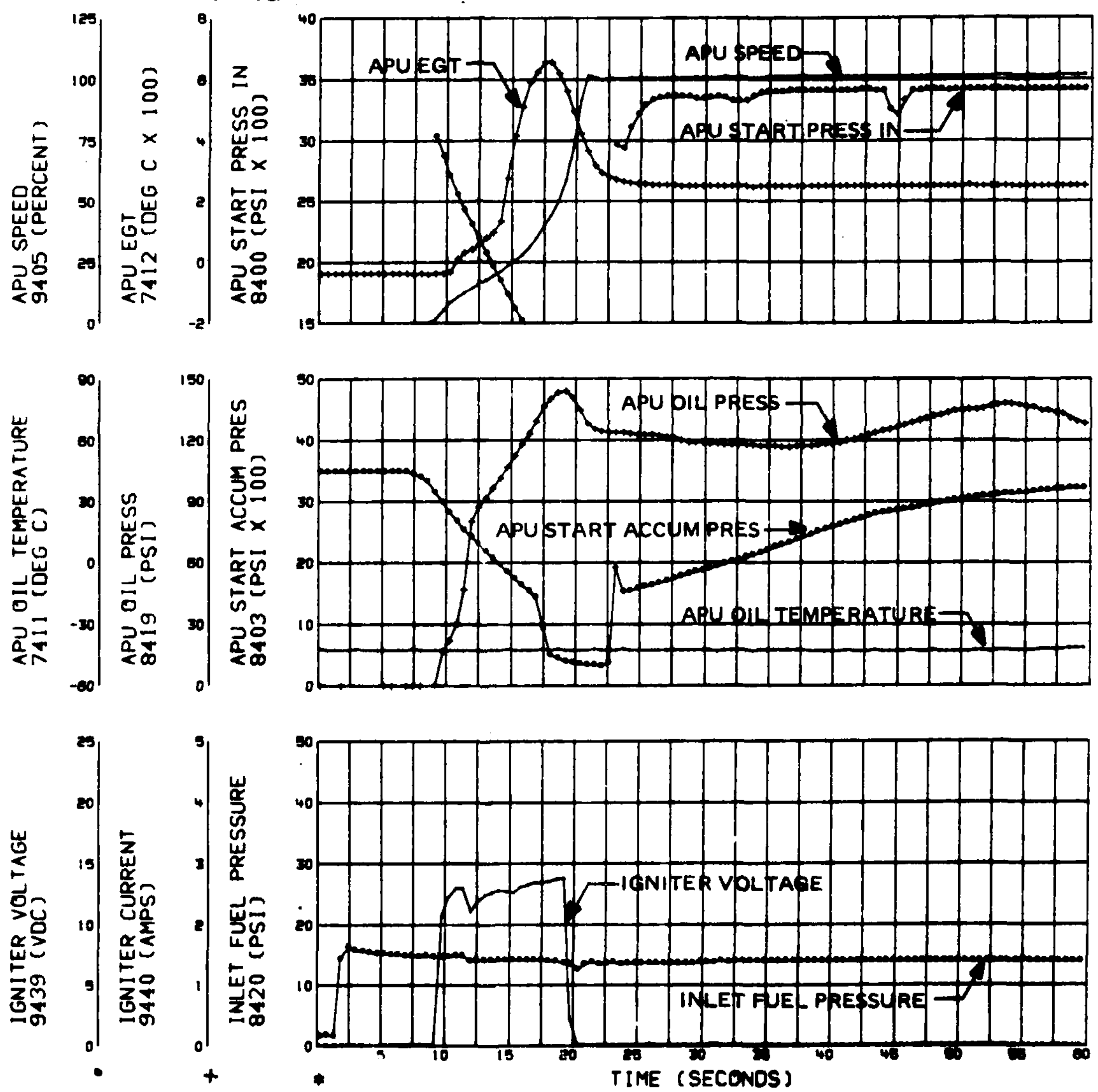


FIGURE 6

APU START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T62-T-2B APU S/N 377312

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FIRST START ATTEMPT AT -65° F
4. IGNITER CURRENT INSTRUMENTATION INOPERATIVE
5. START PRESSURE RATE IS LOW
6. APU START ACCUMULATOR FAILED TO HOLD PRESSURE FOLLOWING THIS ATTEMPT

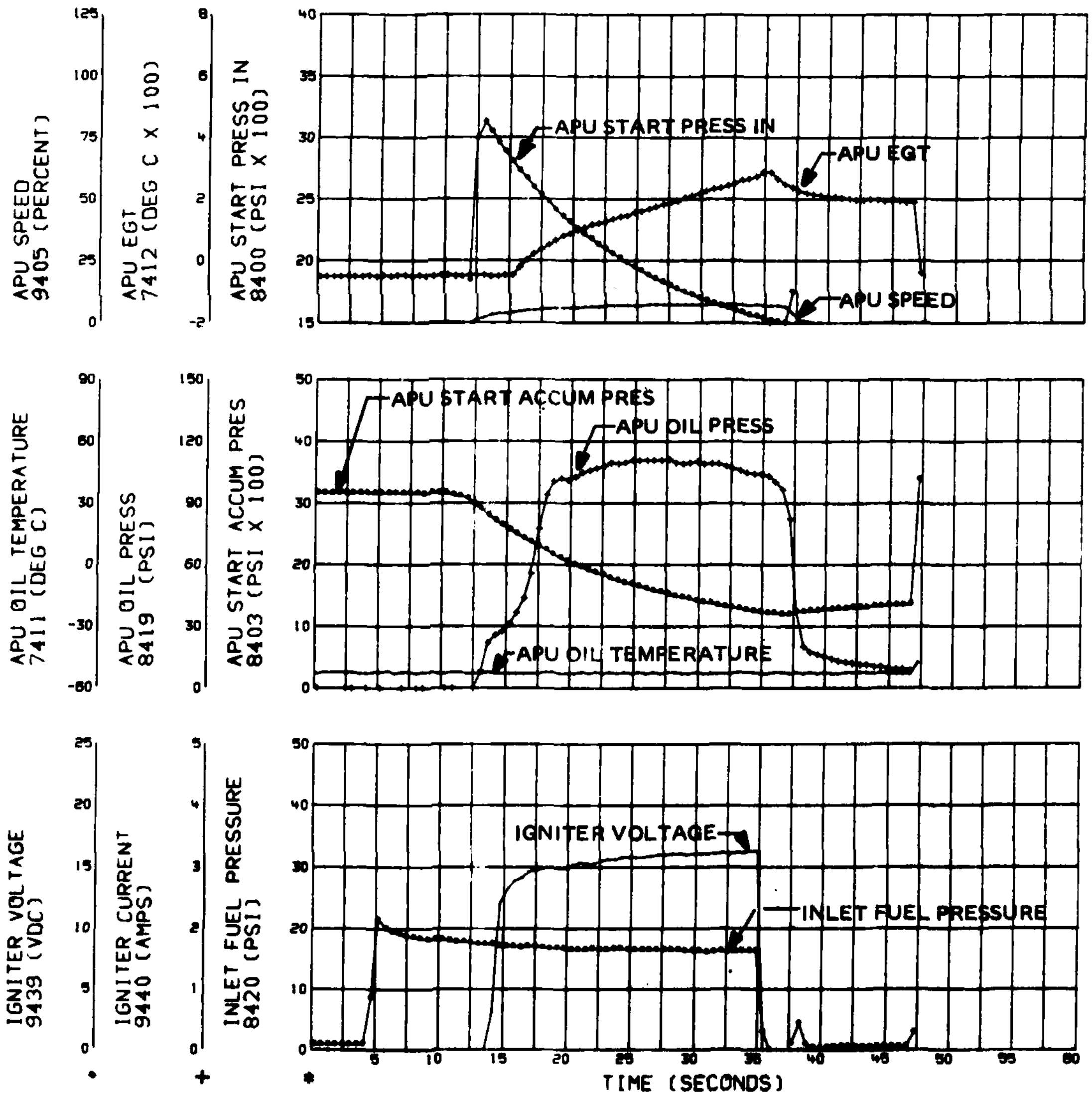


FIGURE 7

APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. APU START ACCUMULATOR FUNCTIONALLY CHECKED AT 65° F AND REINSTALLED
4. FIRST START ATTEMPT
5. 10 MIN HEAT APPLIED TO APU START AND SIGNAL ACCUMULATORS
6. START SELF-ABORT - NO IGNITION
7. IGNITER CURRENT INSTRUMENTATION INOPERATIVE

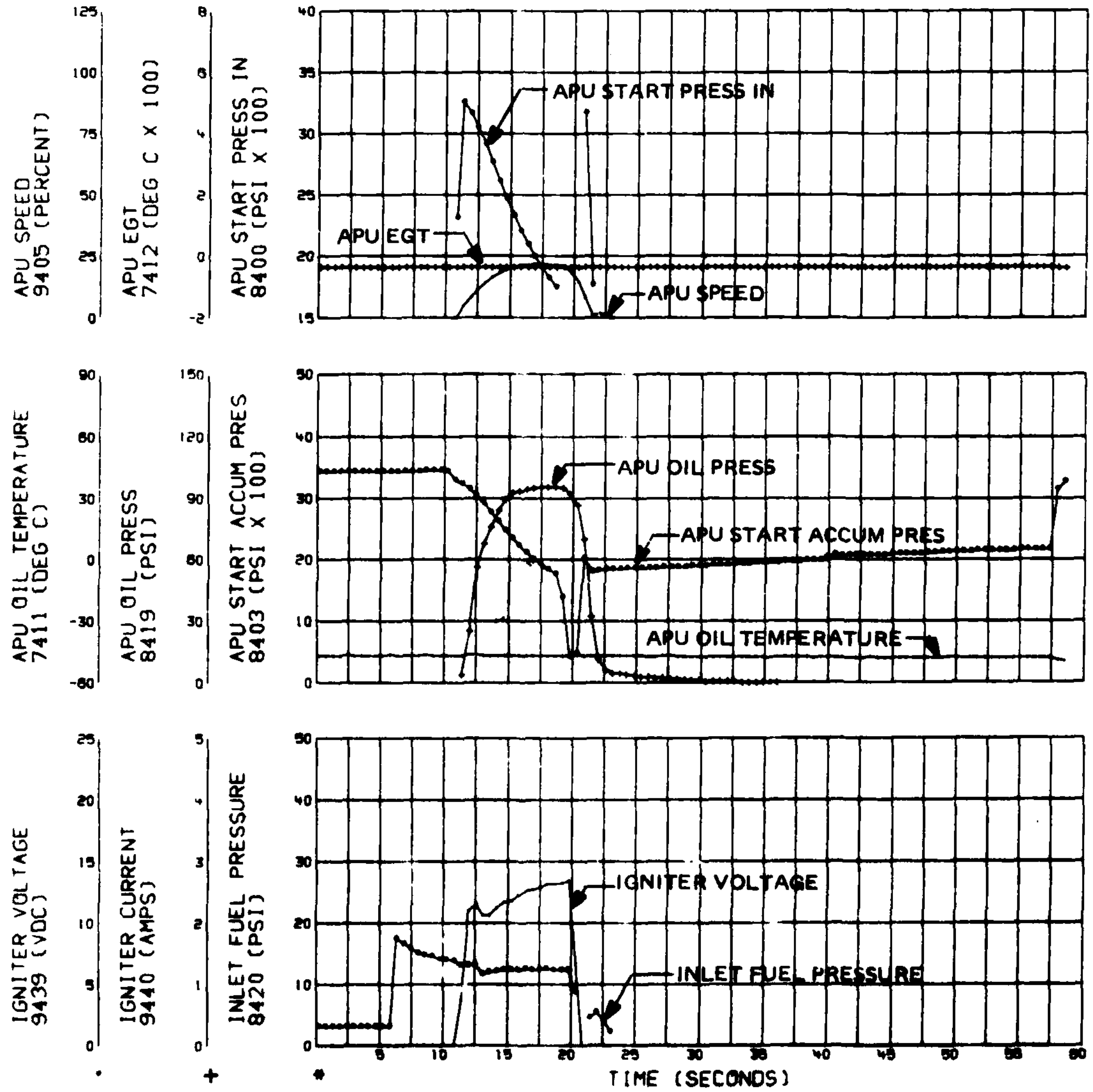


FIGURE 8
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. SECOND START ATTEMPT
4. NO ADDITIONAL HEAT SINCE PREVIOUS ATTEMPT (10 MINUTES SINCE FIRST START ATTEMPT)
5. START SELF-ABORT - NO IGNITION - ICE IN IGNITERS

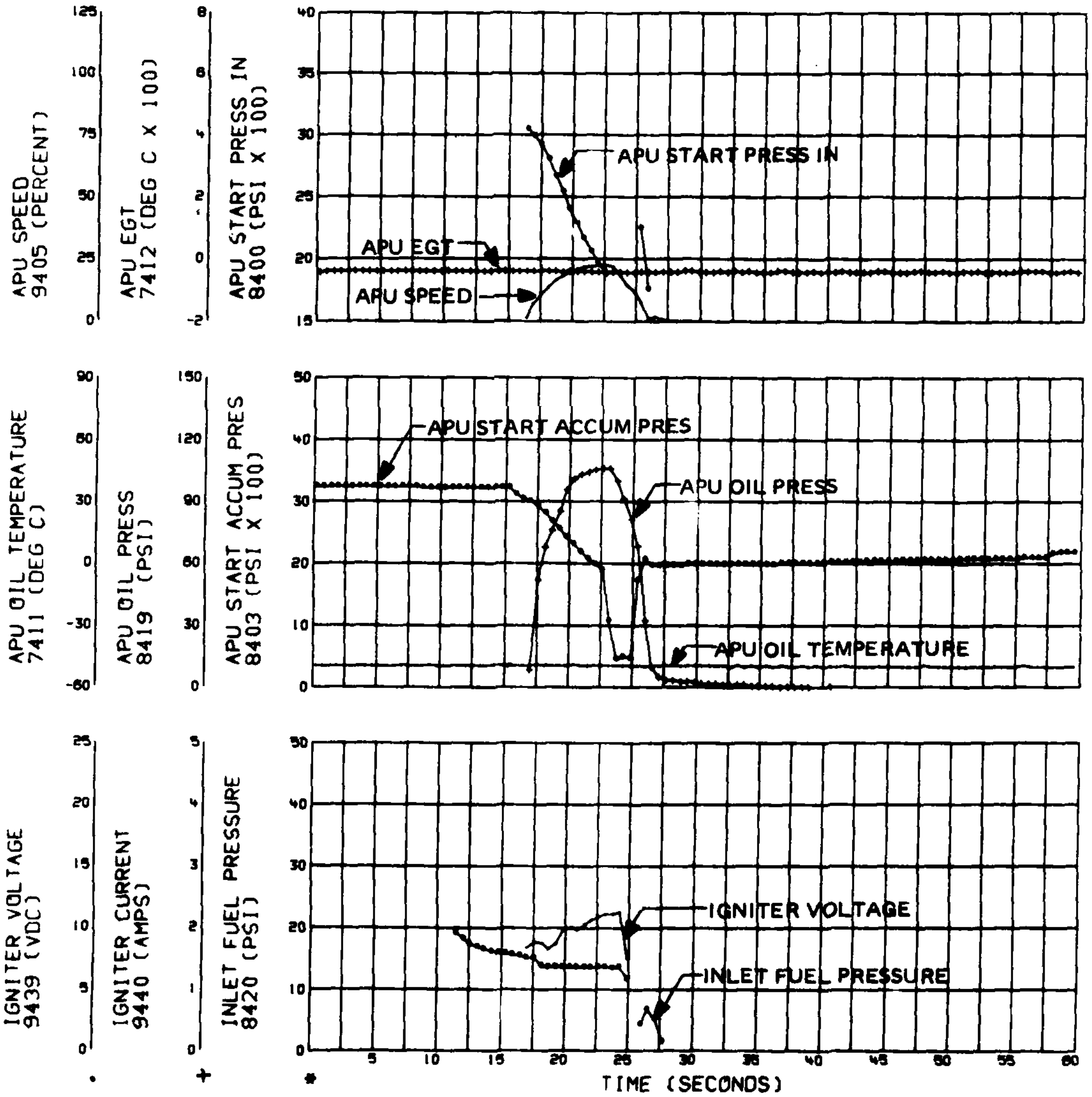


FIGURE 9

APU START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T62-T-2B APU S/N 377312

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. THIRD START ATTEMPT
4. FIVE MINUTES HEAT APPLIED (26 MINUTES SINCE SECOND ATTEMPT)
5. START SELF-ABORT - EGT EXCEEDED 685° C
6. IGNITER CURRENT INSTRUMENTATION INOPERATIVE

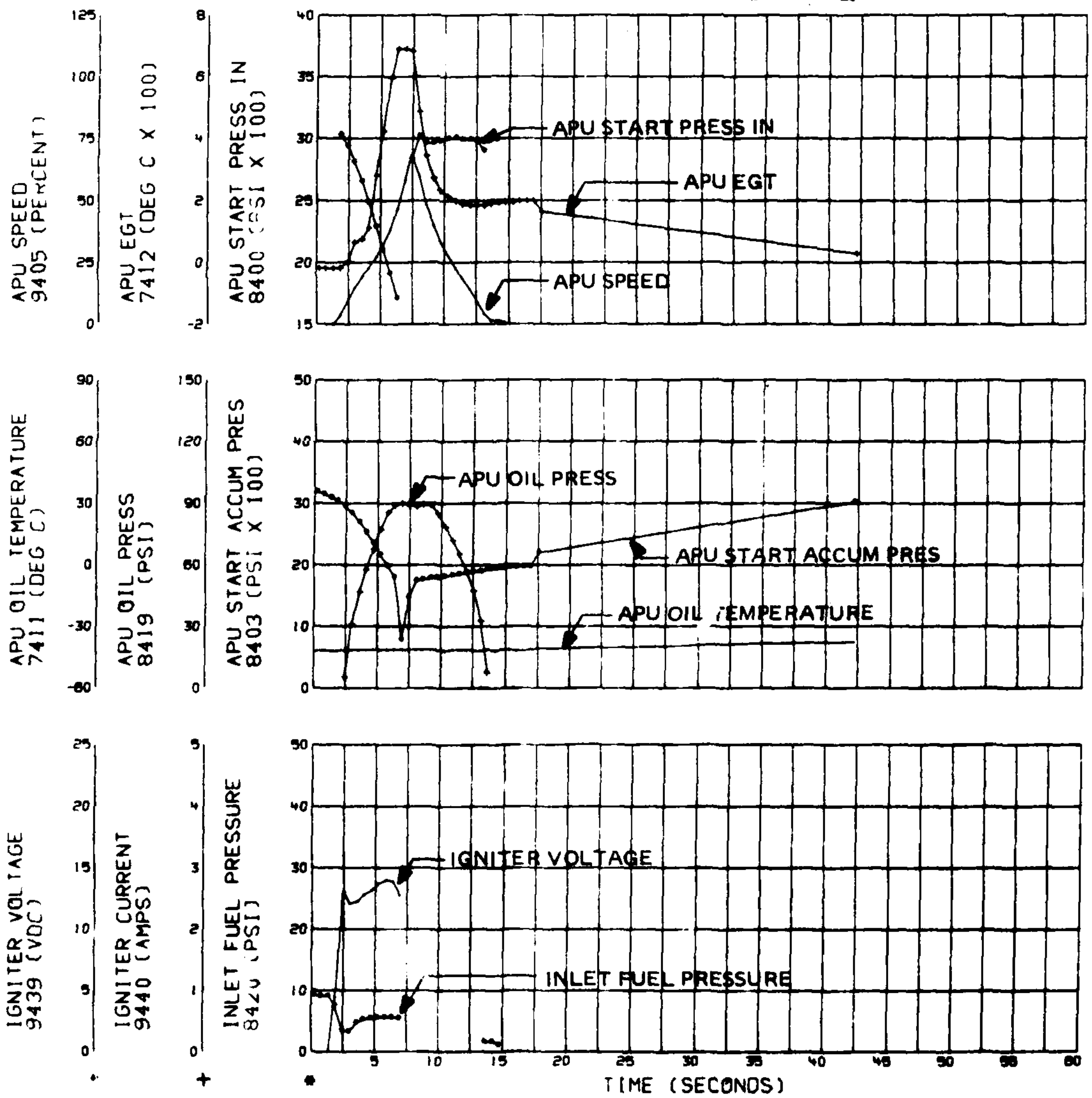


FIGURE 10
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. SUCCESSFUL START FOLLOWING ONE START ATTEMPT (NO HEAT)
4. 10 MINUTES HEAT APPLIED TO APU, AND APU START AND SIGNAL ACCUMULATORS
5. IGNITER CURRENT AND FUEL PRESSURE INSTRUMENTATION INOPERATIVE

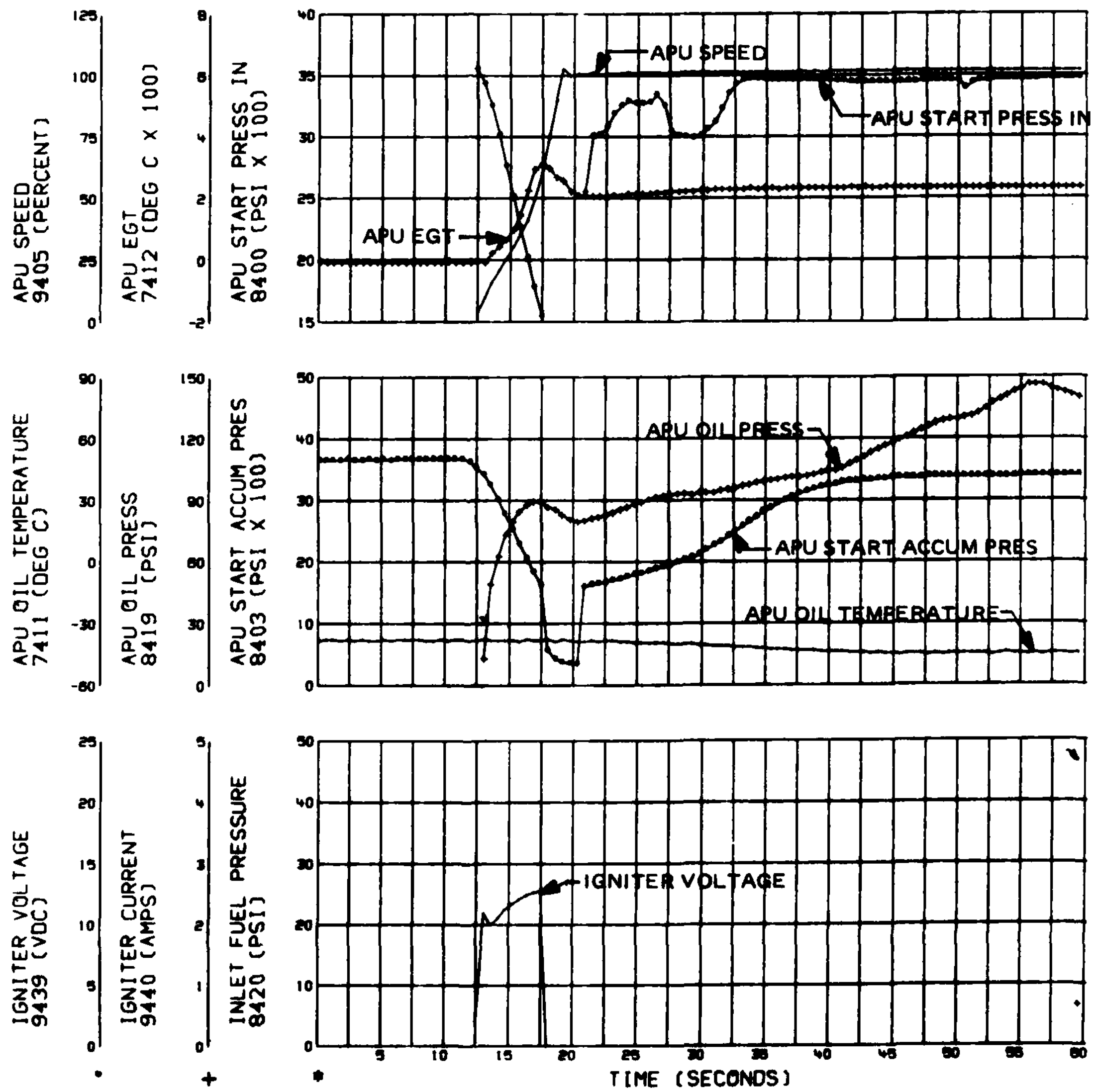


FIGURE 11
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. SUCCESSFUL START ON FIRST ATTEMPT
4. 10 MINUTES HEAT APPLIED TO APU, START ACCUMULATOR, AND SIGNAL ACCUMULATOR
5. IGNITER CURRENT INSTRUMENTATION INOPERATIVE

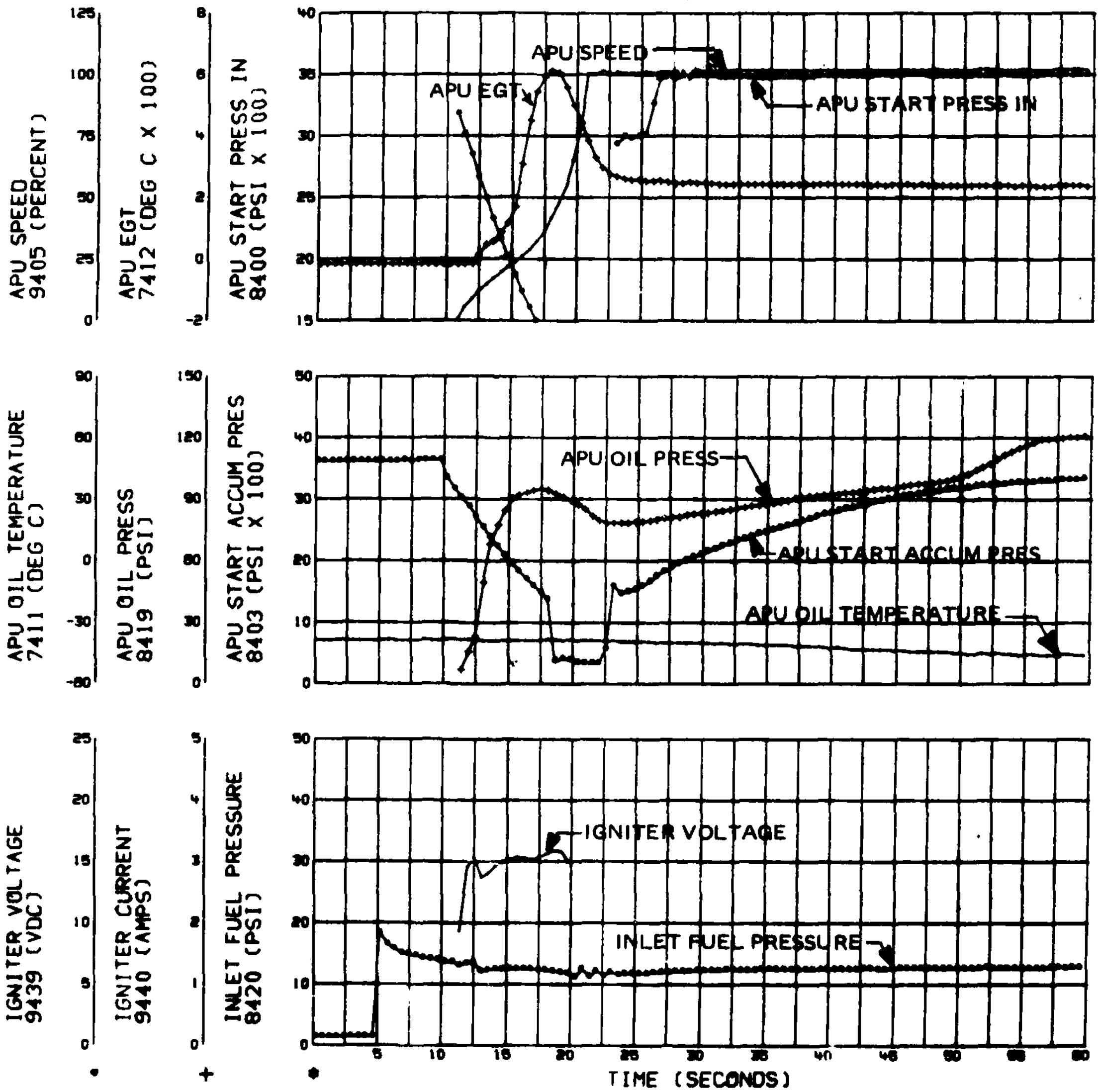


FIGURE 12
APU START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

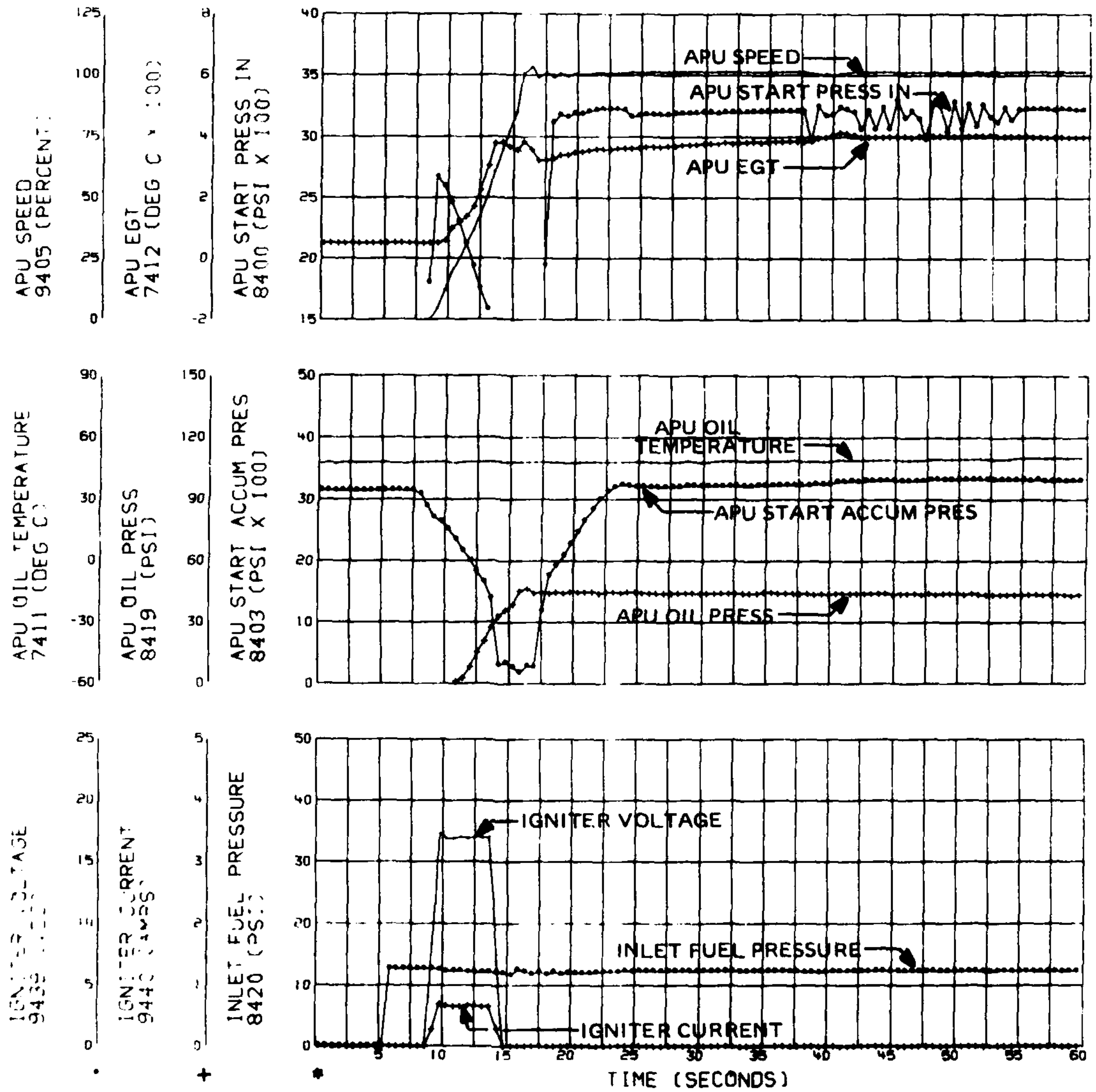
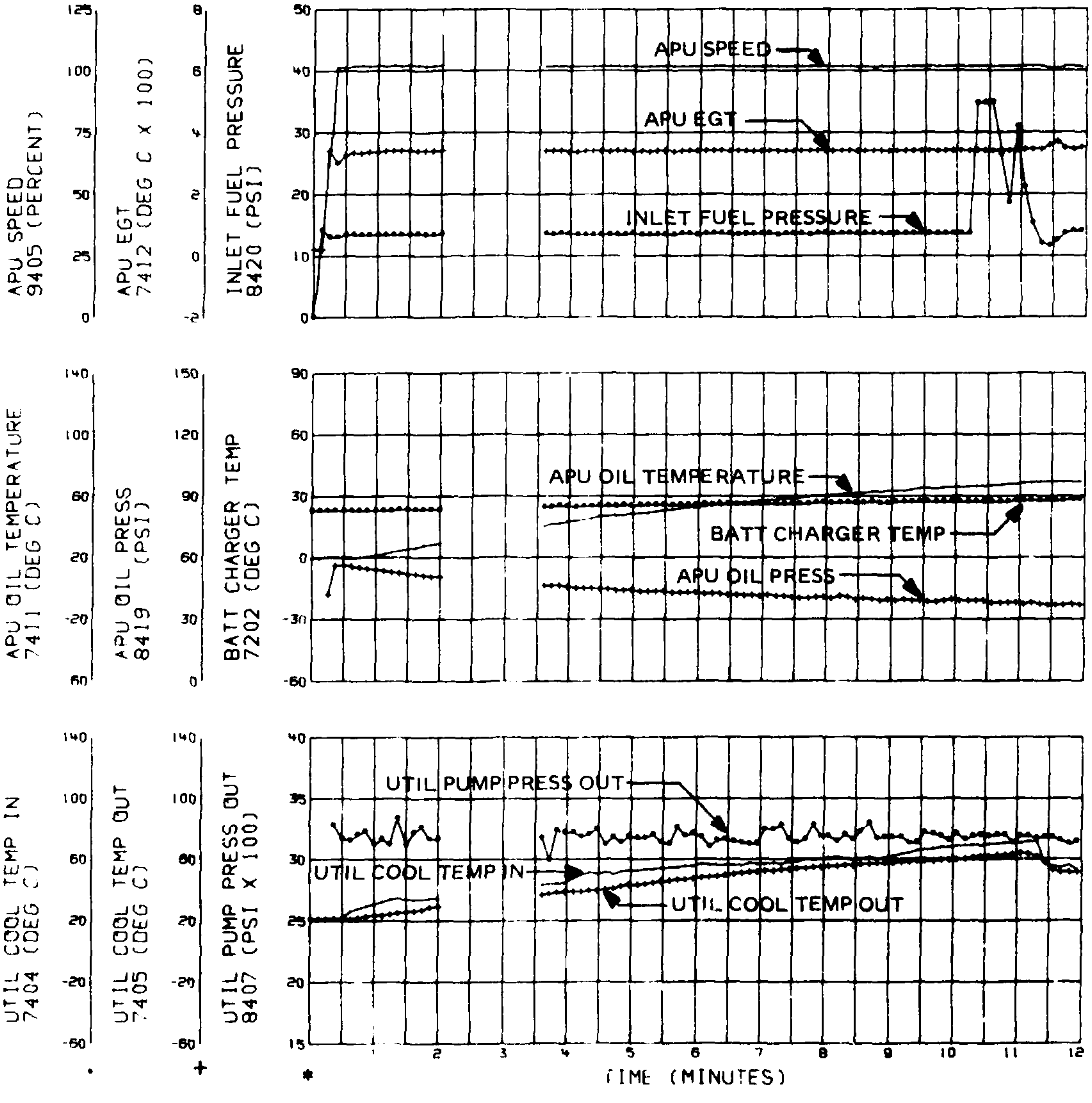


FIGURE 13
APU WARM-UP/RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES:
1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. INLET FUEL PRESSURE UNRELIABLE LAST 2 MINUTES
4. ALL PARAMETERS INOPERATIVE FOR 1½ MINUTES
5. RUN ACCOMPLISHED SUBSEQUENT TO -65° F TESTING



AD-A115 861 ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB CA F/G 1/3
CLIMATIC LABORATORY EVALUATION YCH-47D HELICOPTER.(U)
AUG 81 J R NIEMANN, C F ADAM, J A BROWN
UNCLASSIFIED USAAEFA-79-13 NL

2 OF 3
AD
A115861

FIGURE 14
APU WARM-UP/RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES:
1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. INLET FUEL PRESSURE UNRELIABLE LAST 3 MINUTES

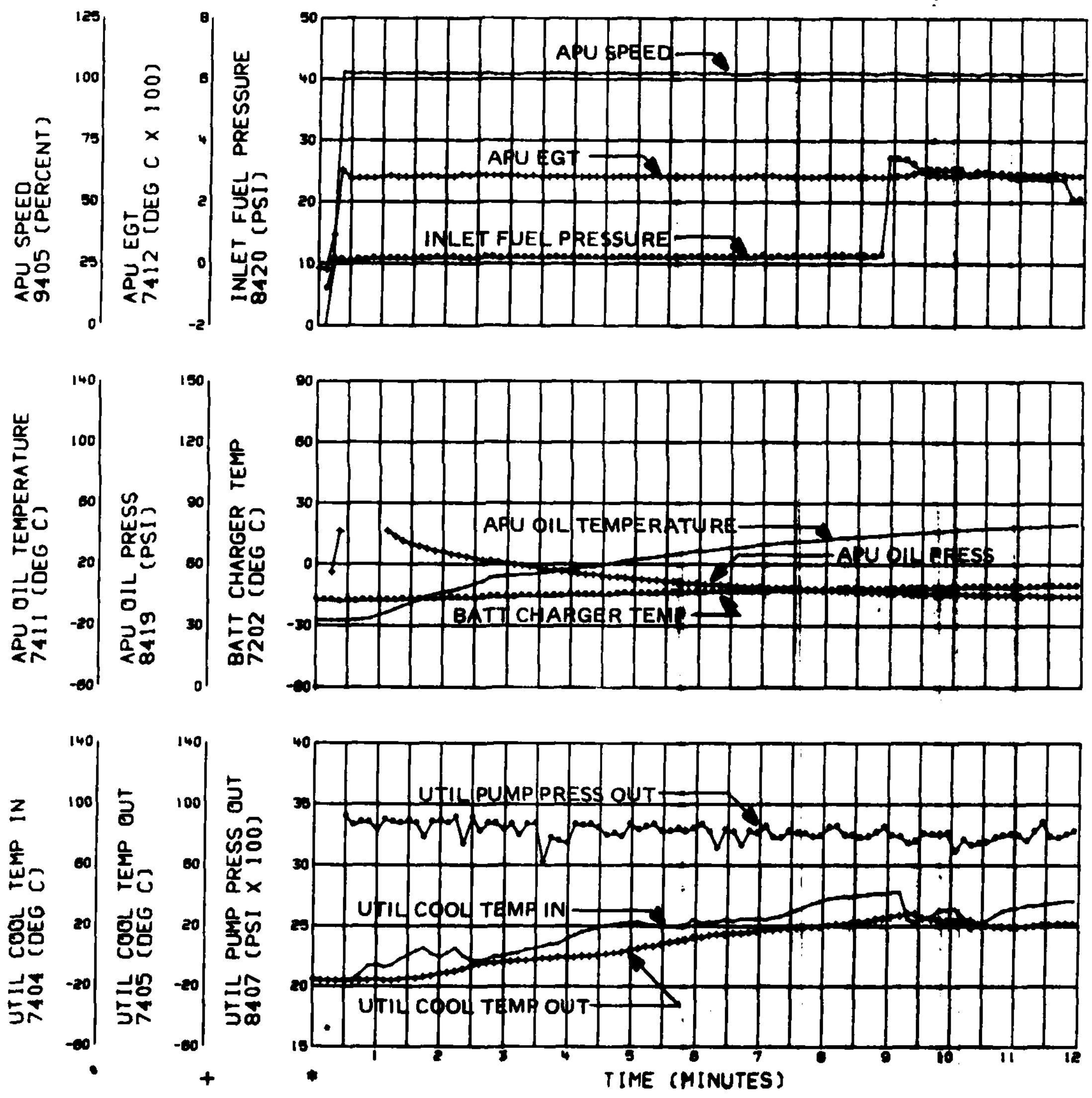


FIGURE 15
APU WARM-UP/RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES: 1. APU SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

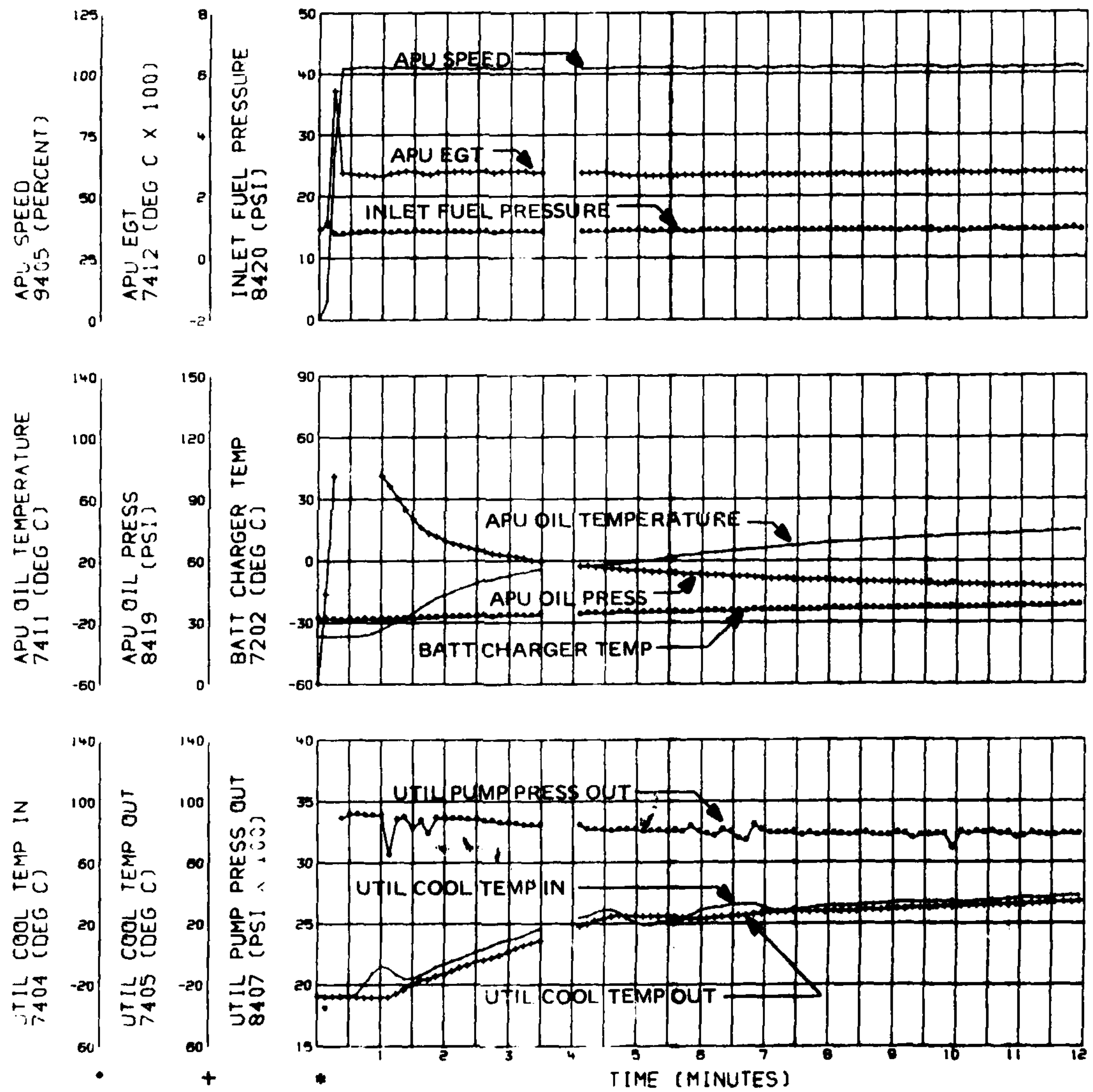


FIGURE 16
APU WARM-UP/RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

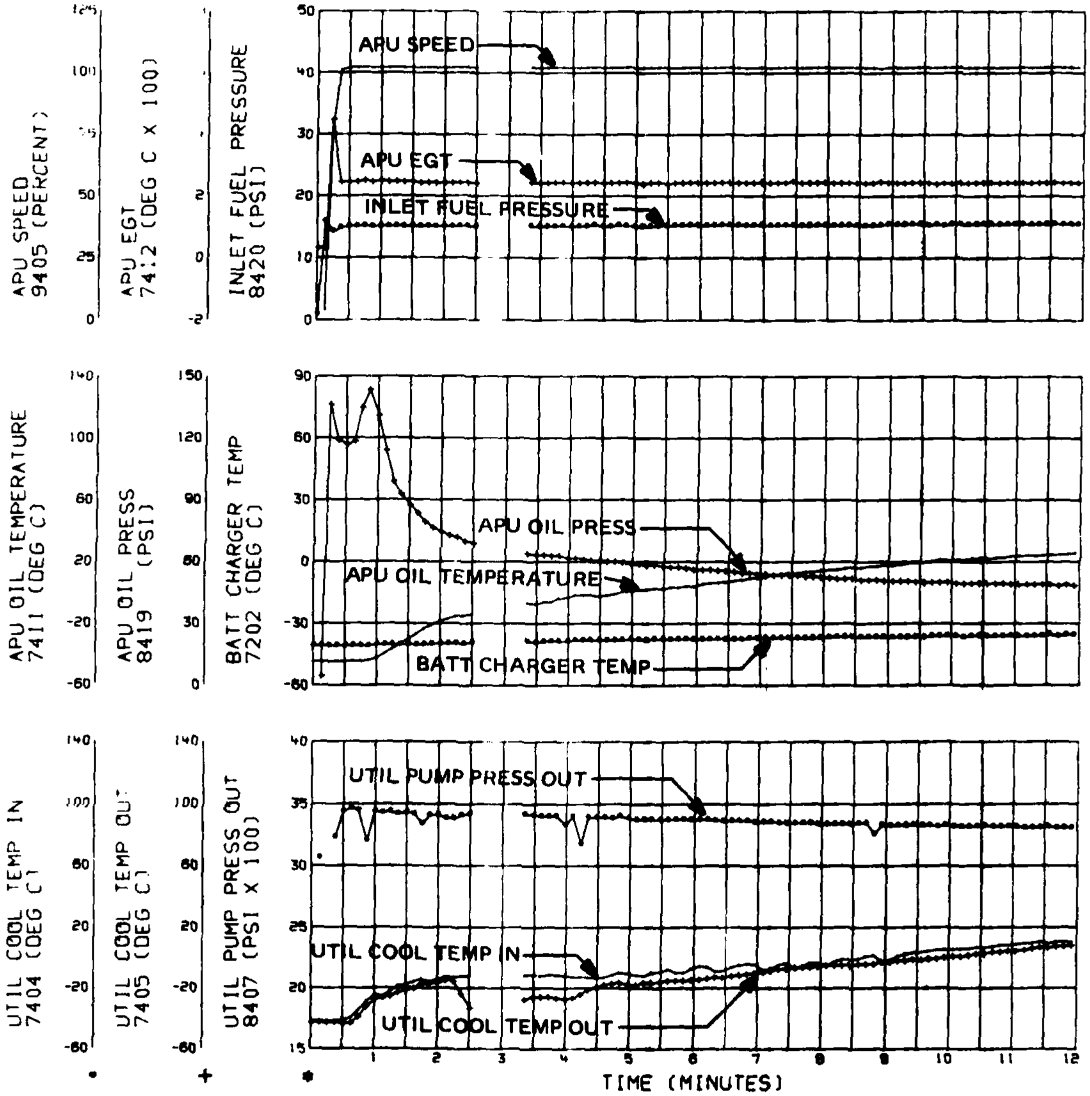


FIGURE 17
APU WARM-UP/RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

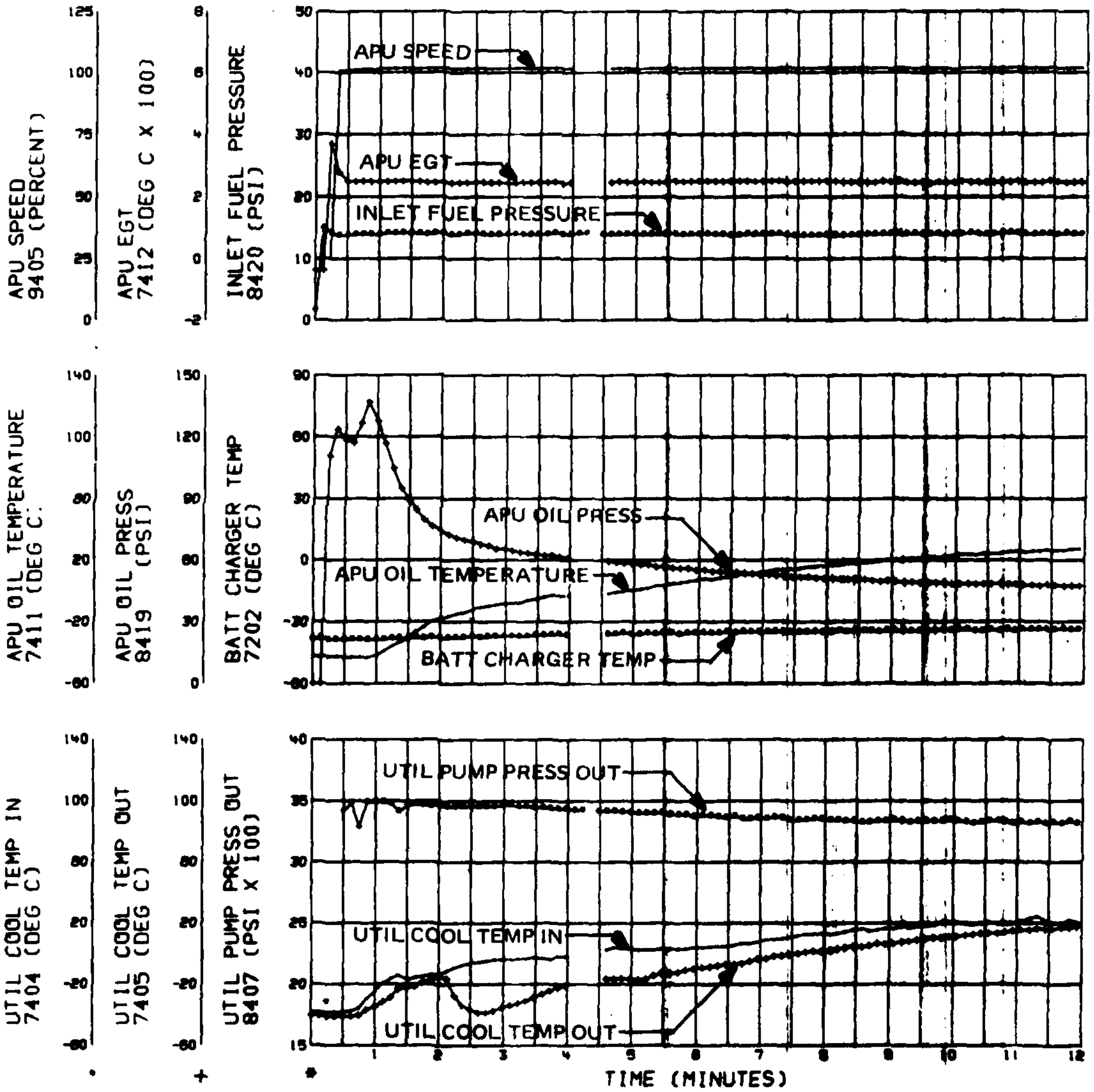


FIGURE 18
APU WARM-UP/RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T62-T-2B APU S/N 377312
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. APU SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

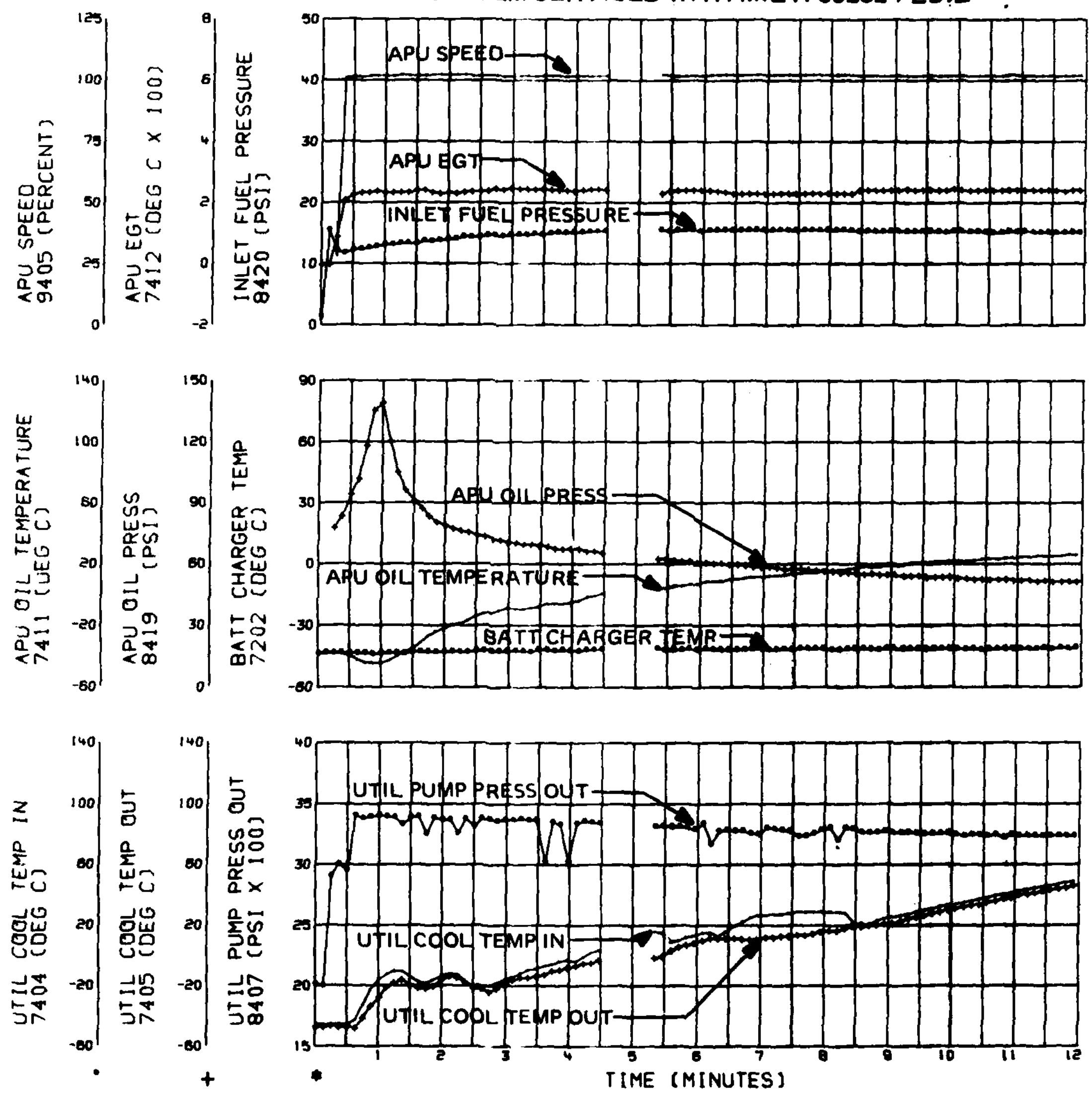


FIGURE 19

APU WARM-UP/RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T62-T-2B APU S/N 377312

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. APU SERVICED WITH MIL-L-23699 OIL

2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

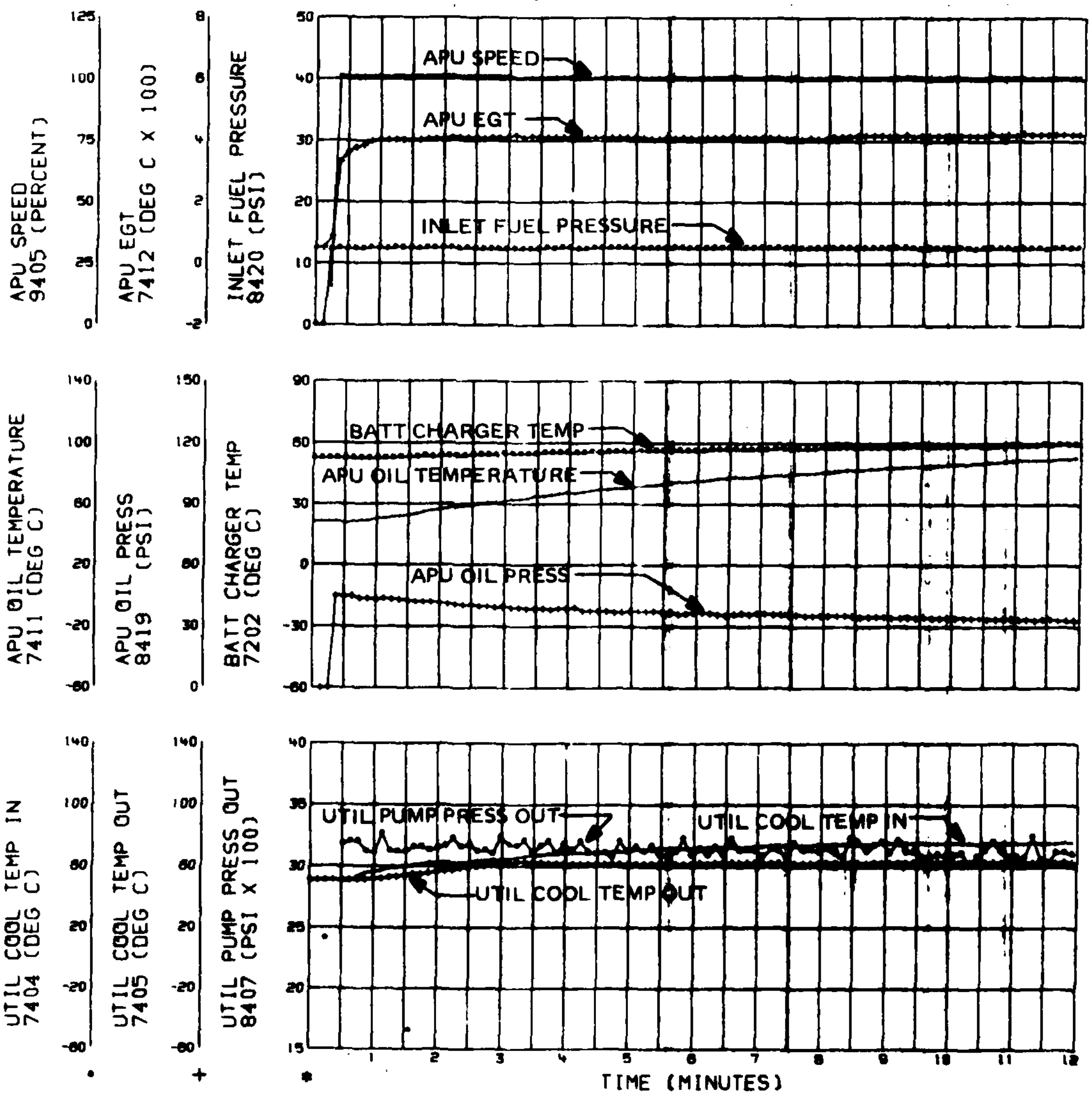


FIGURE 20
NO. 1 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19566
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. START ACCOMPLISHED SUBSEQUENT TO -65° F TESTING

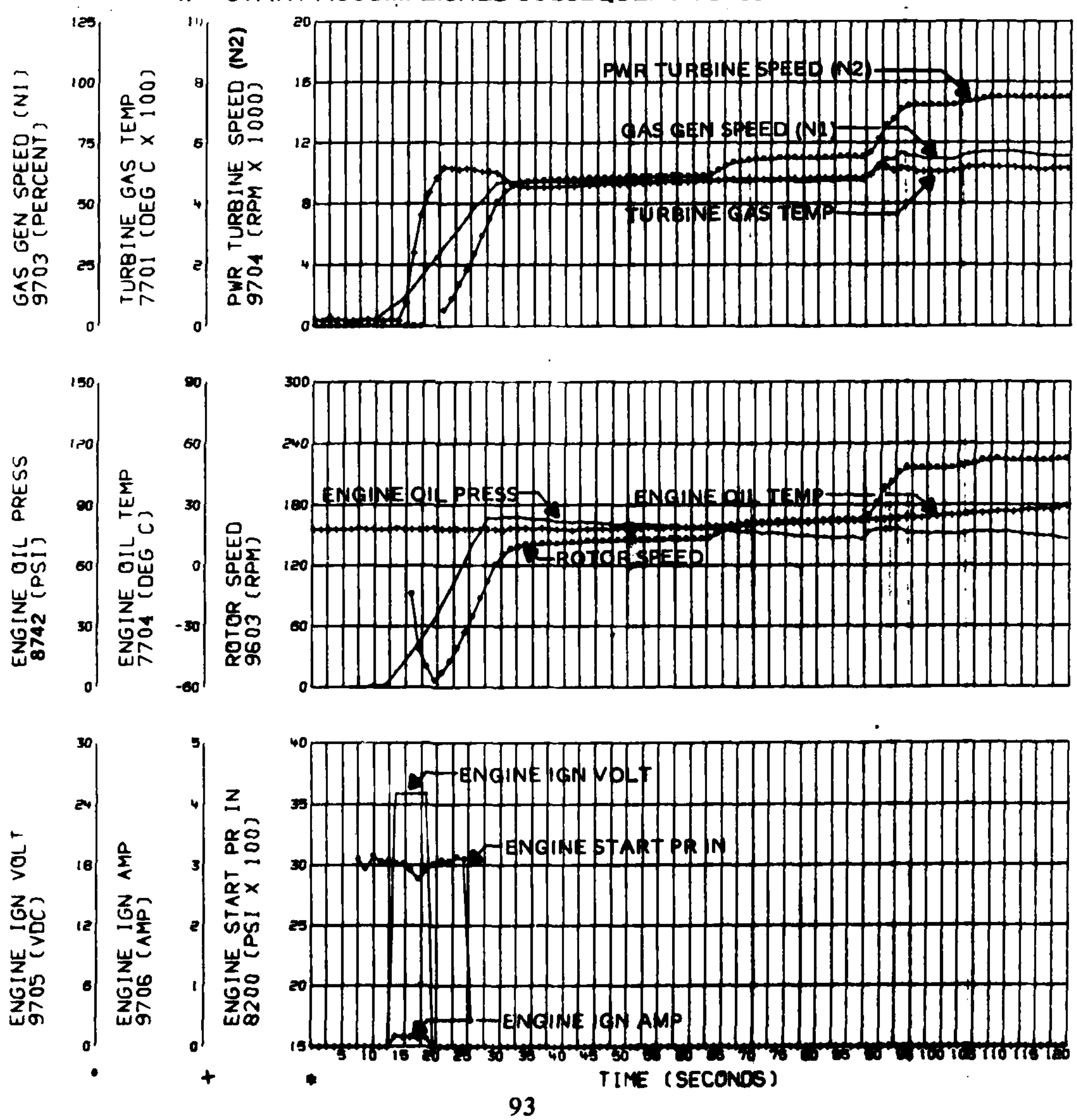


FIGURE 21
NO. 1 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19566
CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. NO. 2 ENGINE STARTED FIRST
5. N_1 AND ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

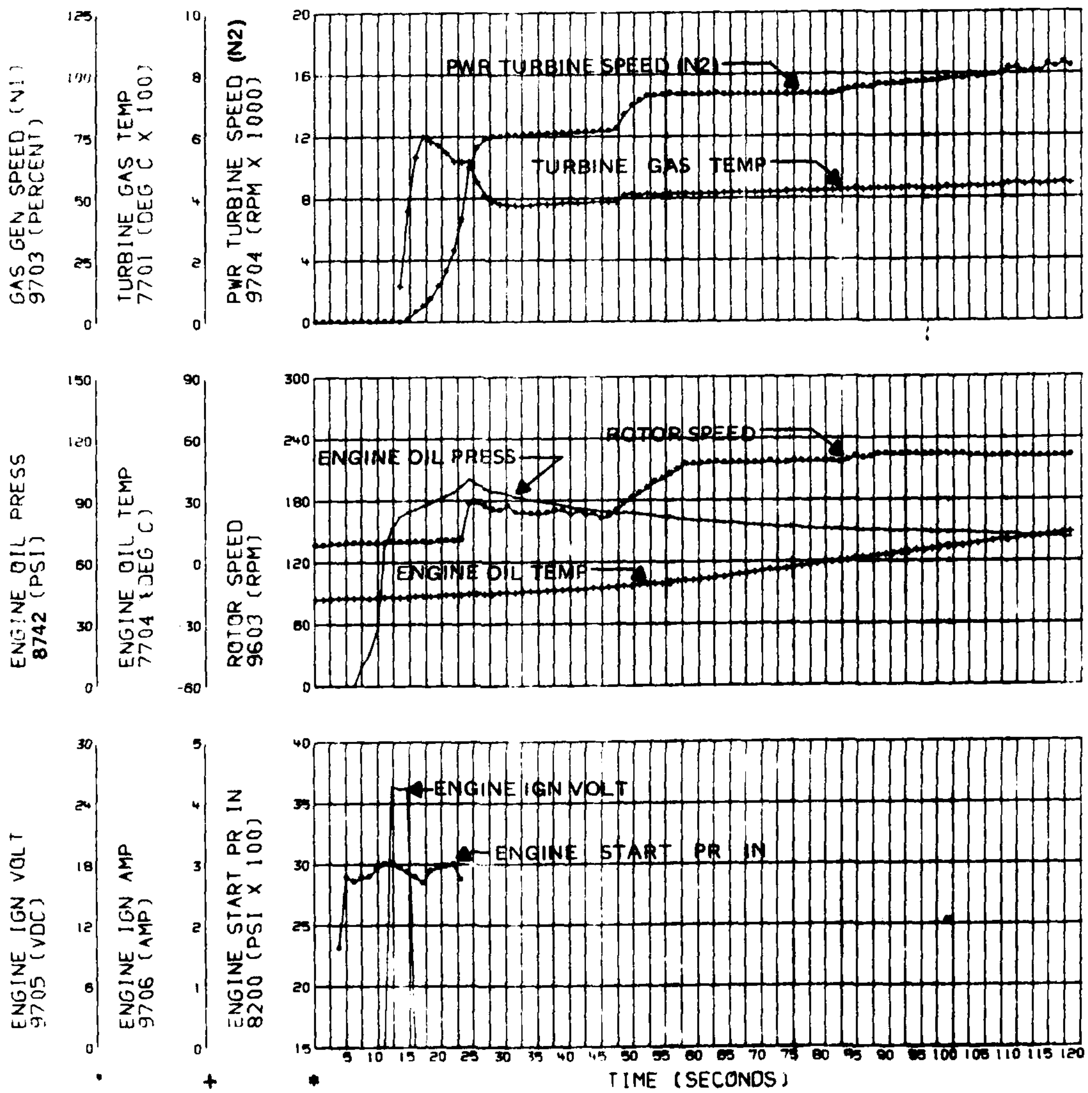


FIGURE 22

NO. 1 ENGINE START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. NO. 2 ENGINE STARTED FIRST
5. N_2 AND ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

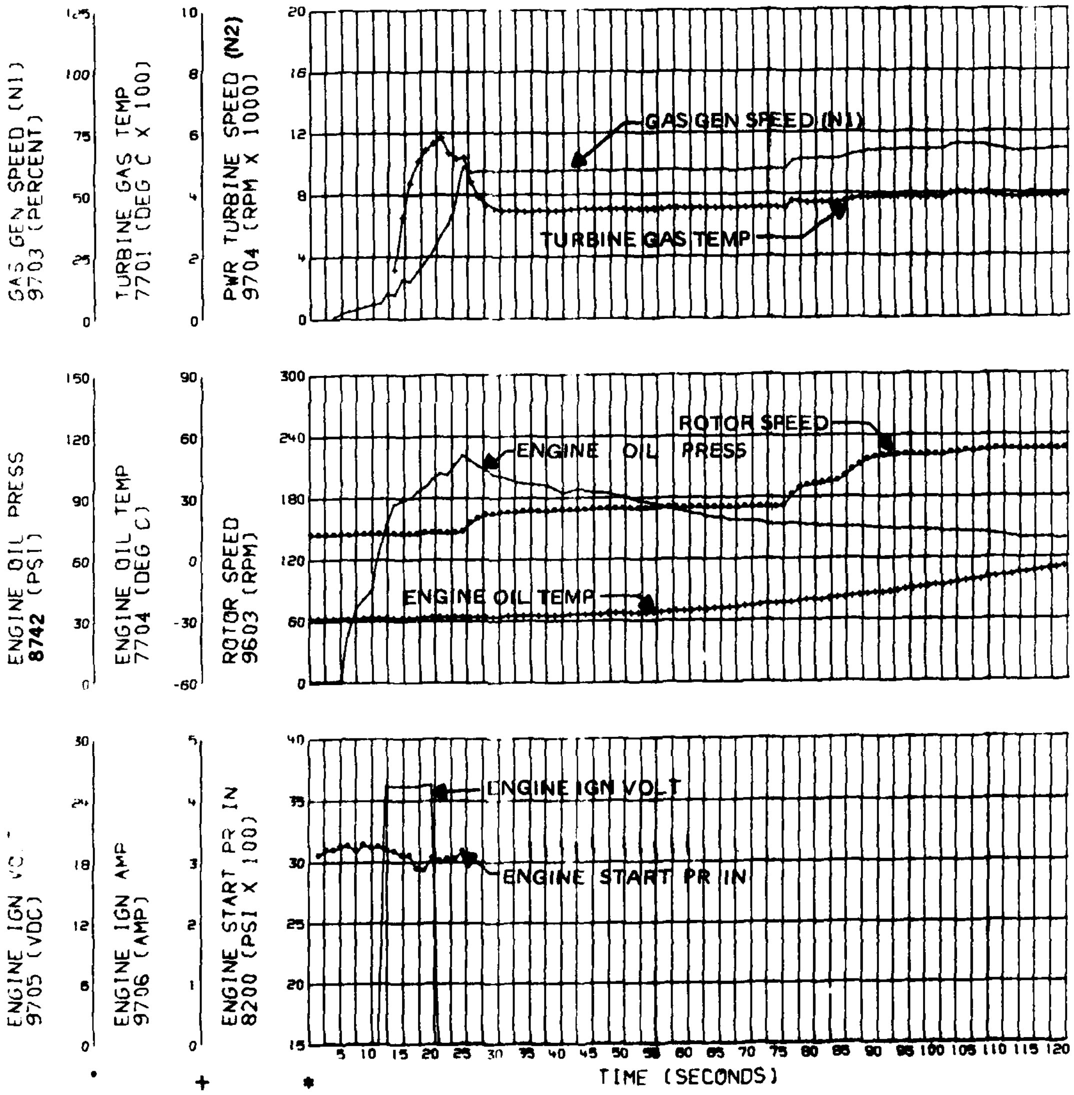


FIGURE 23

NO. 1 ENGINE START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-4 FUEL UTILIZED
4. ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

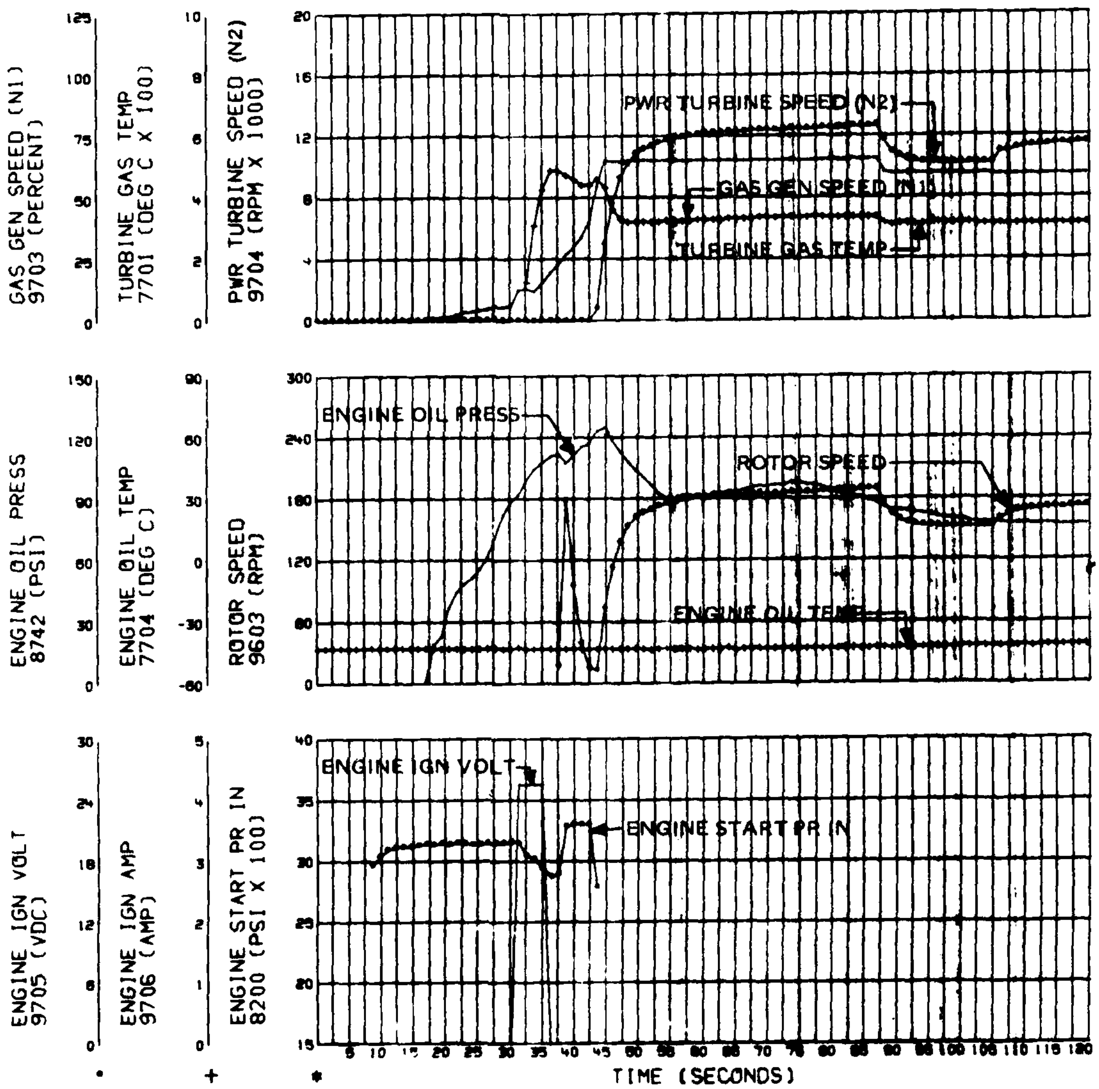


FIGURE 24
NO. 1 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19566
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-4 FUEL UTILIZED
4. NO. 2 ENGINE STARTED FIRST
5. ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

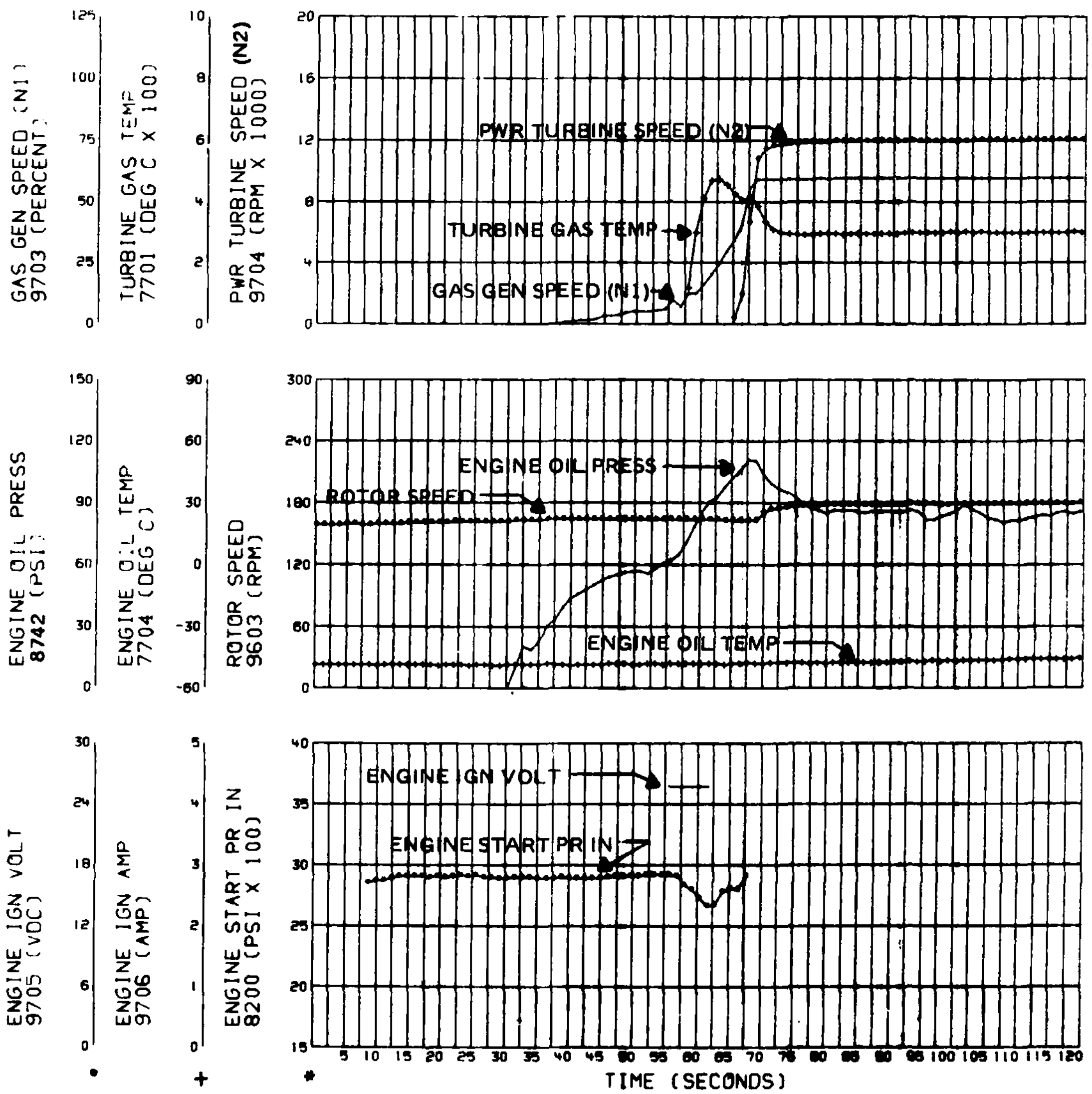


FIGURE 25
NO. 1 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19566
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. NO. 2 ENGINE STARTED FIRST

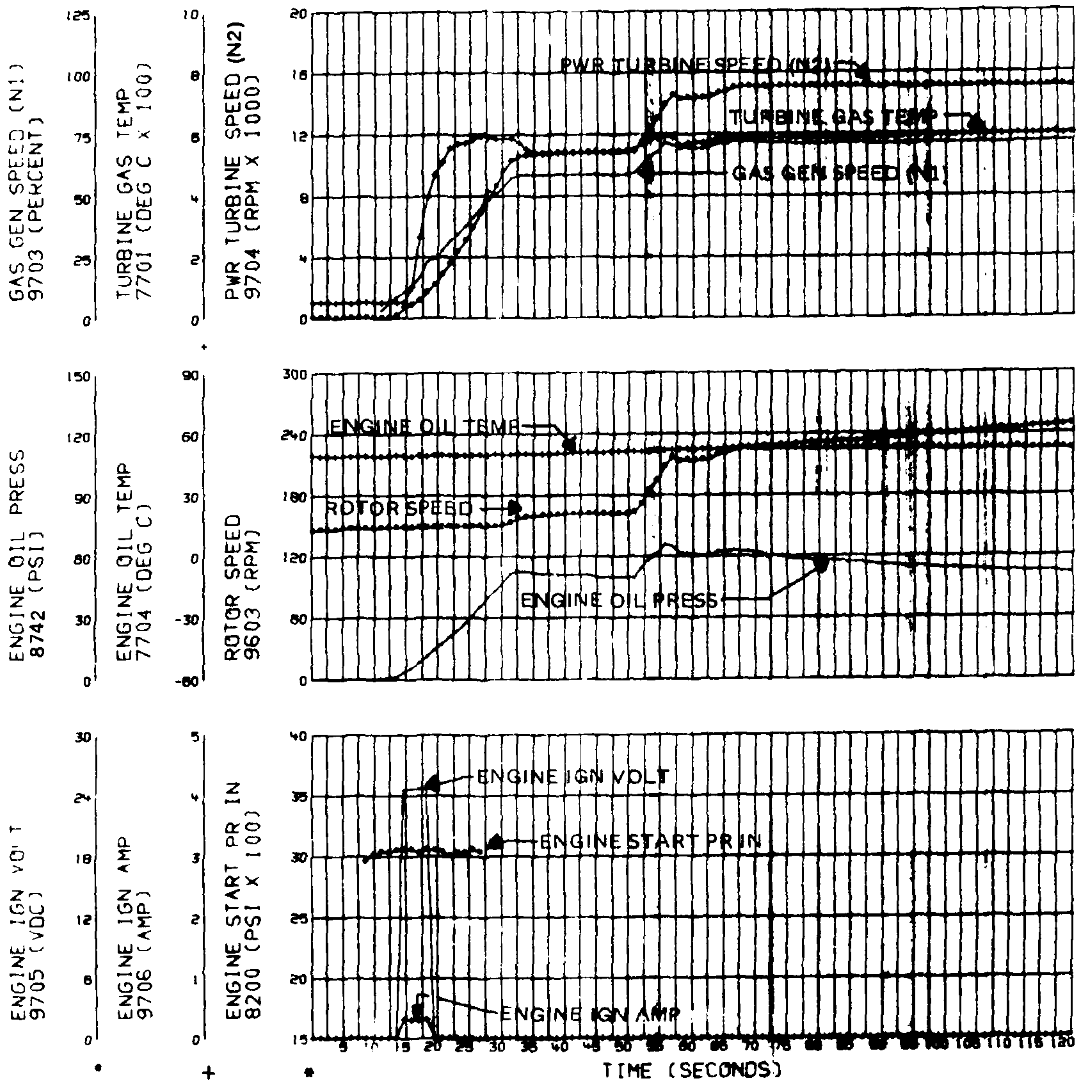


FIGURE 26

NO. 1 ENGINE START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE 125° F

ENGINE RESTART

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. NO. 1 ENGINE SHUTDOWN WITH IMMEDIATE RESTART
5. NO. 2 ENGINE WAS RUNNING AT NO. 1 ENGINE SHUTDOWN

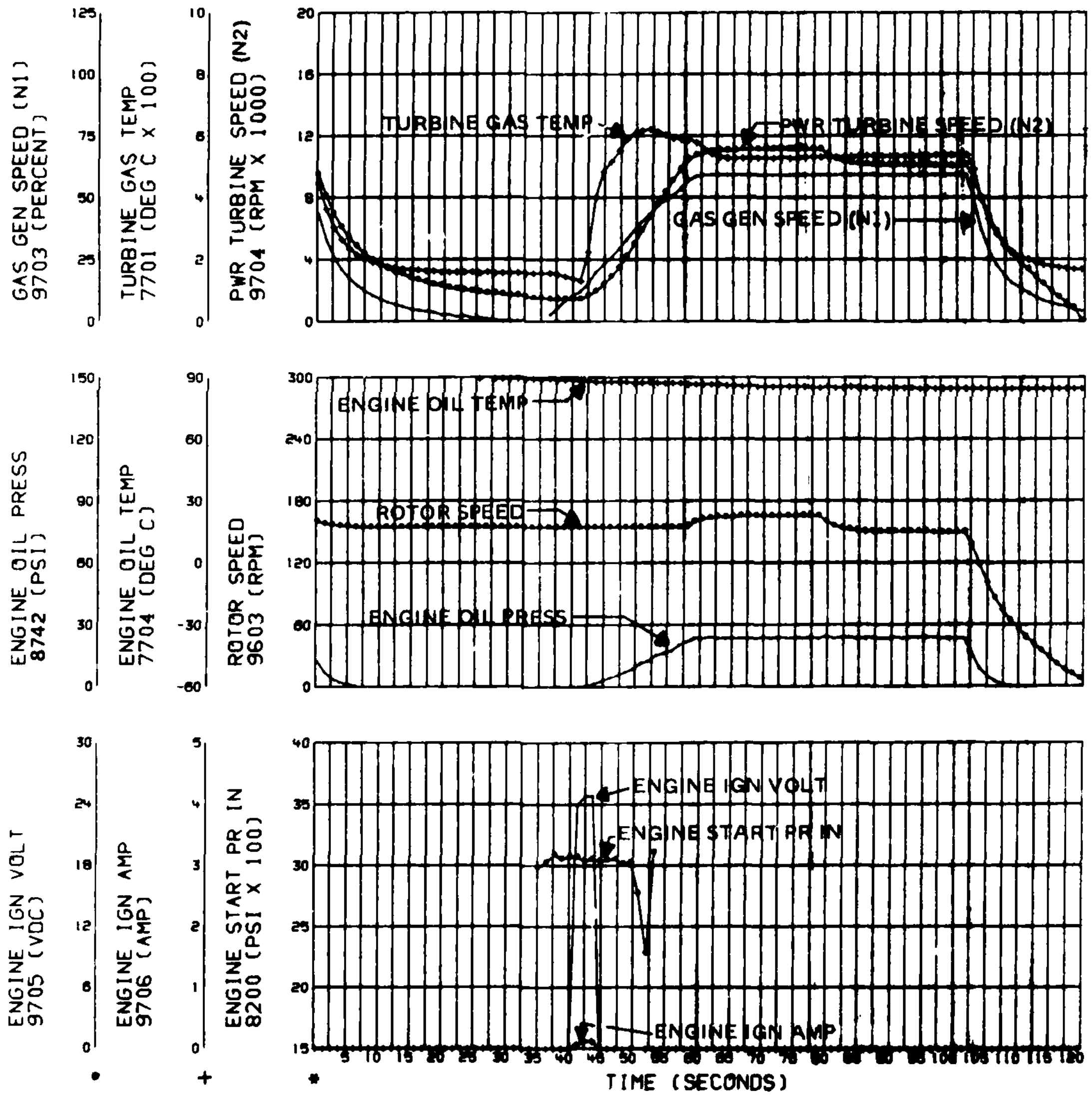


FIGURE 27
NO. 2 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19296
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. START ACCOMPLISHED SUBSEQUENT TO -65° F TESTING
5. NO. 1 ENGINE STARTED FIRST
6. ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

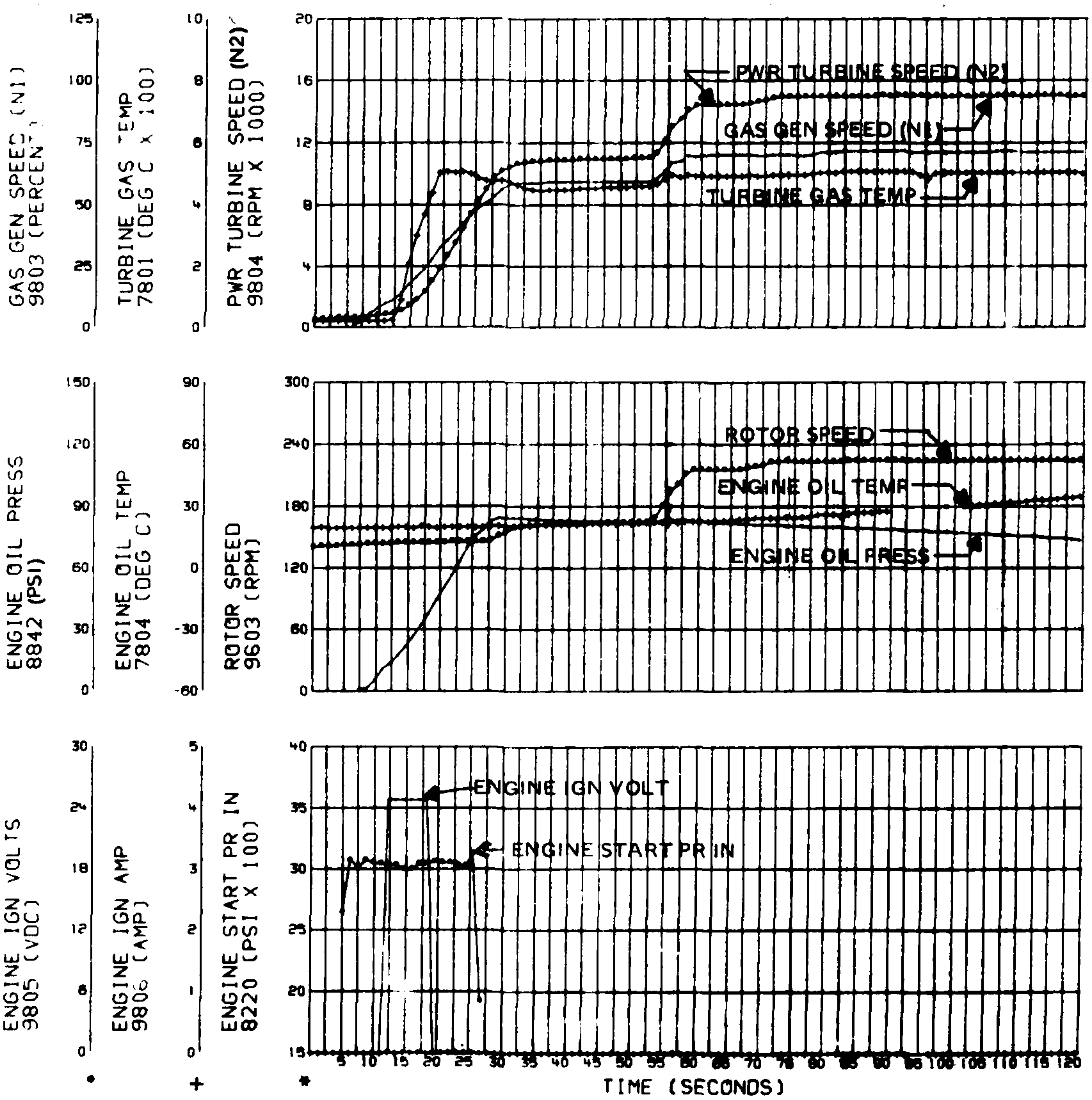


FIGURE 28

NO. 2 ENGINE START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. N_1 AND ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

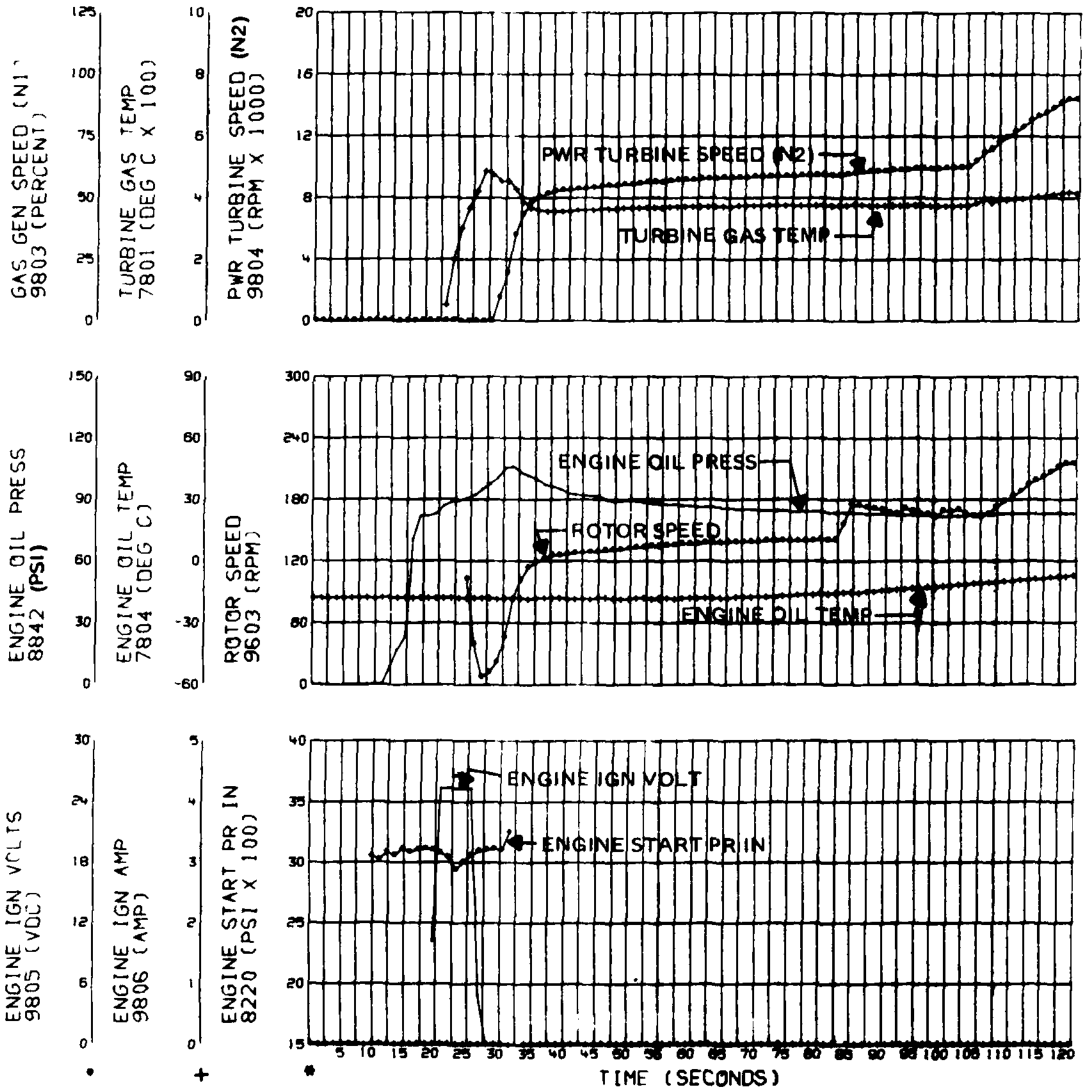


FIGURE 29

NO. 2 ENGINE START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

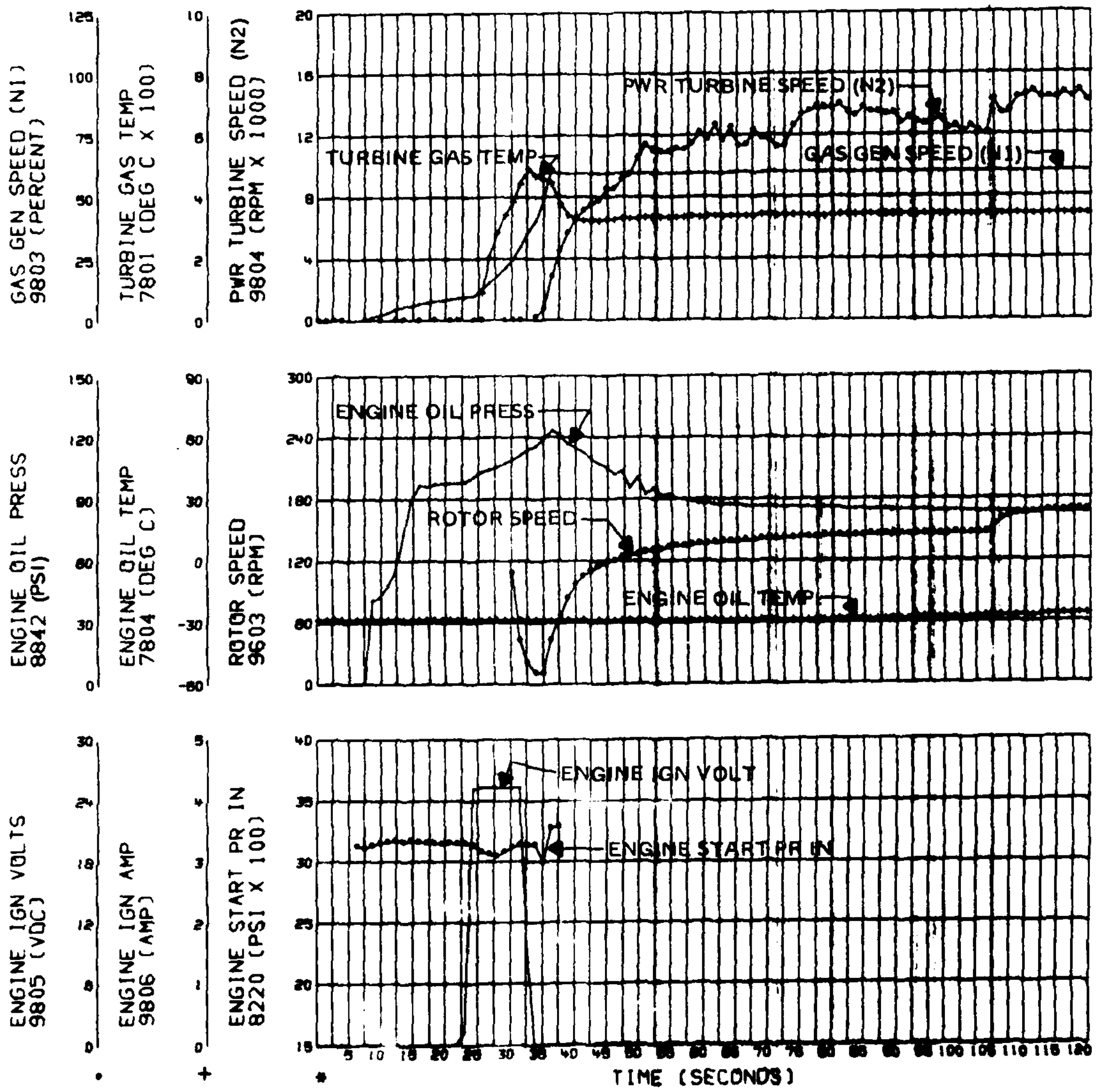


FIGURE 30
NO. 2 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19296
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-4 FUEL UTILIZED
4. NO. 1 ENGINE STARTED FIRST
5. ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

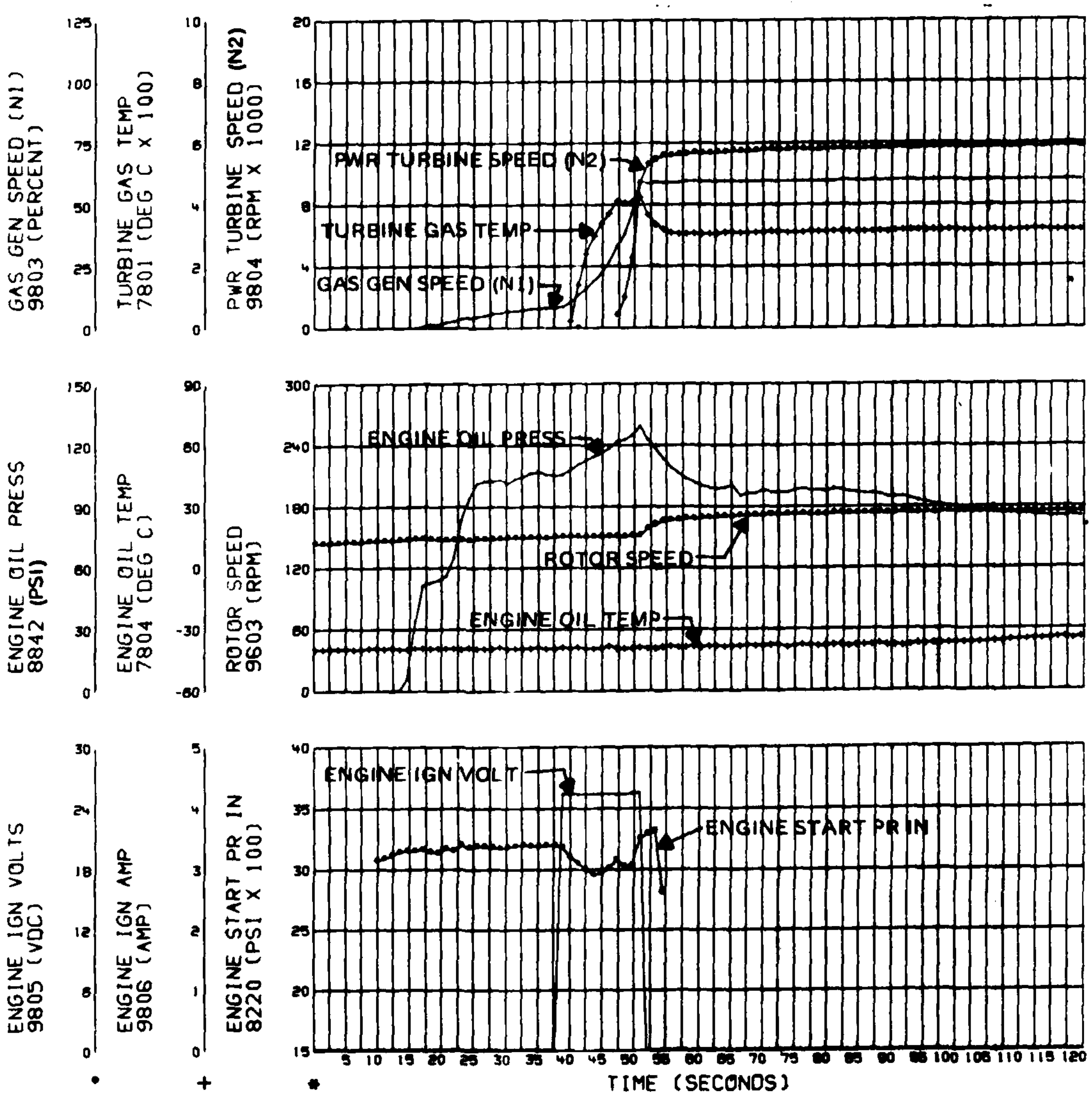


FIGURE 31

NO. 2 ENGINE START CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-4 FUEL UTILIZED
4. ENGINE IGNITER AMP INSTRUMENTATION INOPERATIVE

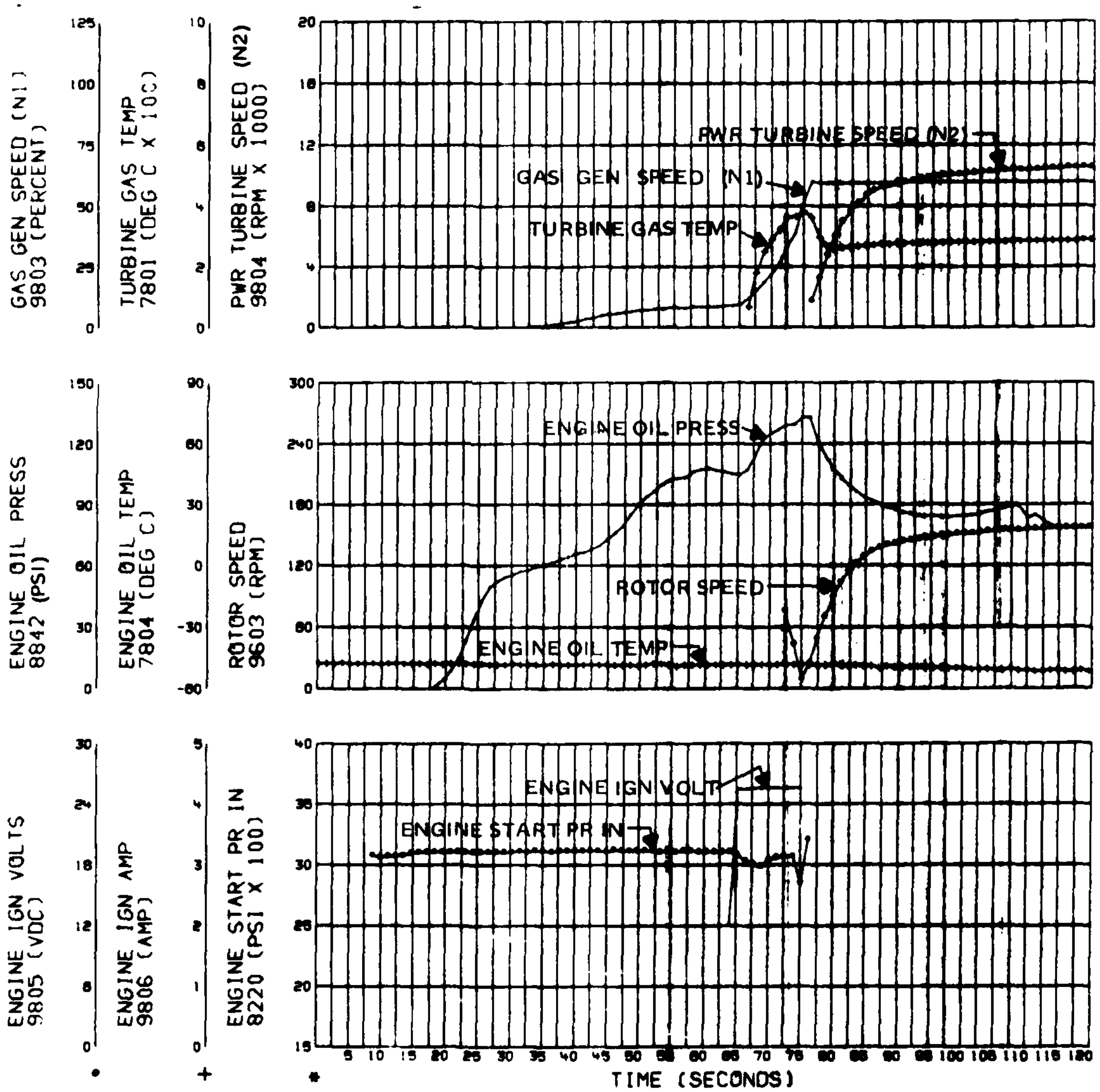


FIGURE 32
NO. 2 ENGINE START CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19296
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. JP-5 FUEL UTILIZED
4. NO. 1 ENGINE STARTED FIRST
5. ENGINE IGNITER AMP UNRELIABLE

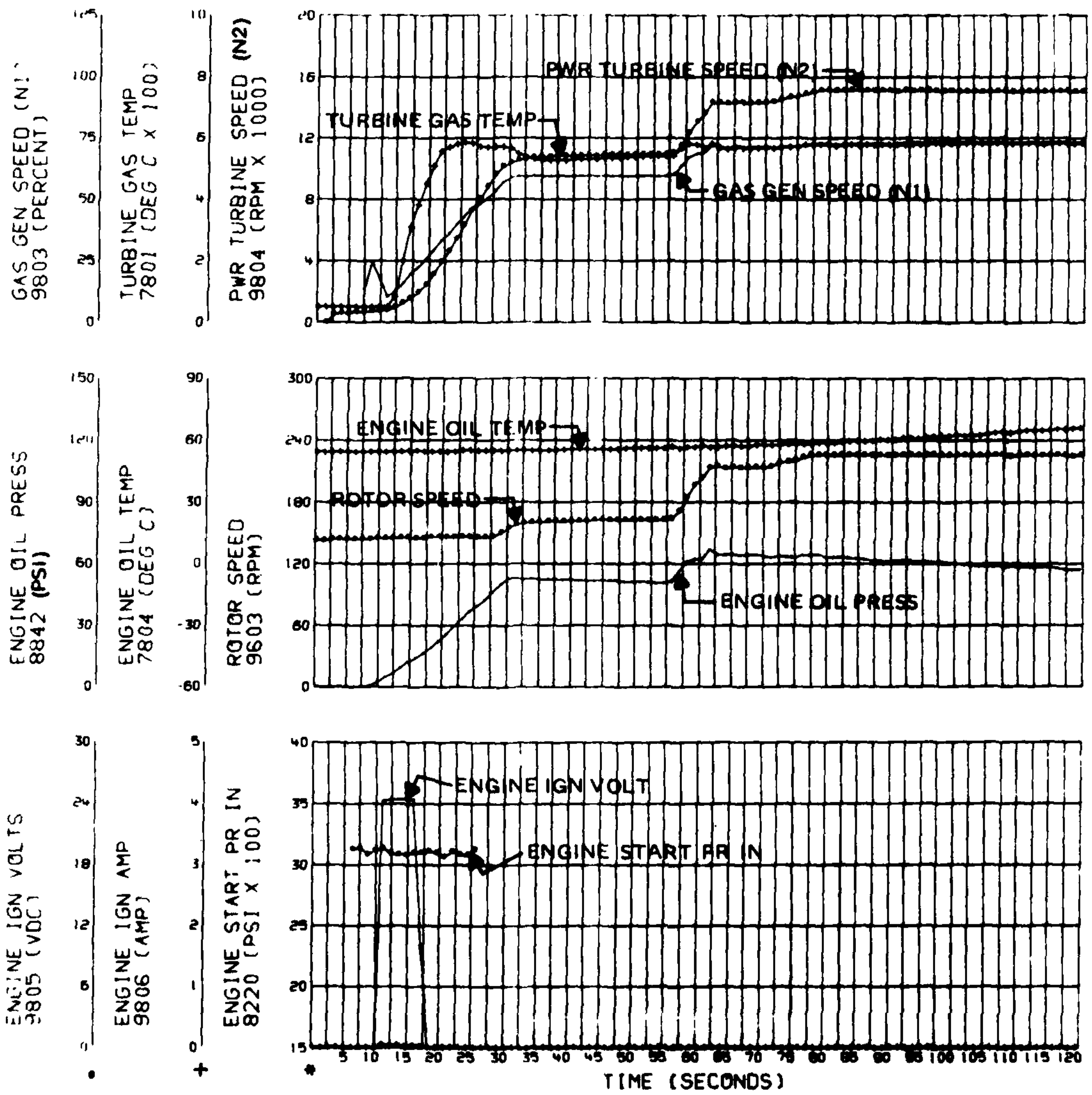


FIGURE 33
NO. 1 ENGINE RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19566
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. JP-5 FUEL UTILIZED
3. RUN ACCOMPLISHED SUBSEQUENT TO -65°F TESTING

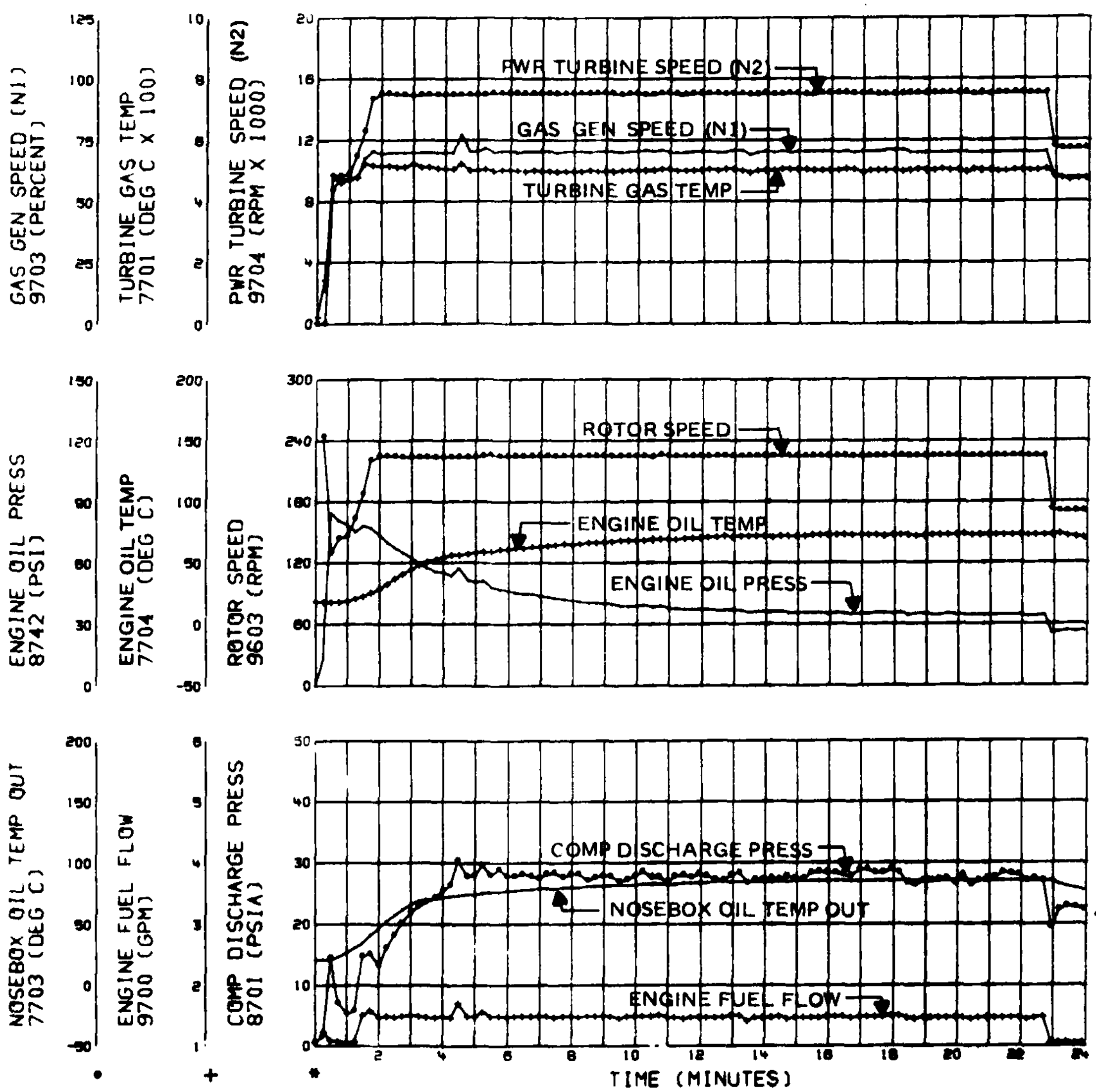


FIGURE 34

NO. 1 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING LNGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. JP-5 FUEL UTILIZED
3. COMPRESSOR DISCHARGE PRESSURE UNRELIABLE
4. N_1, N_2, TGT INSTRUMENTATION INOPERATIVE

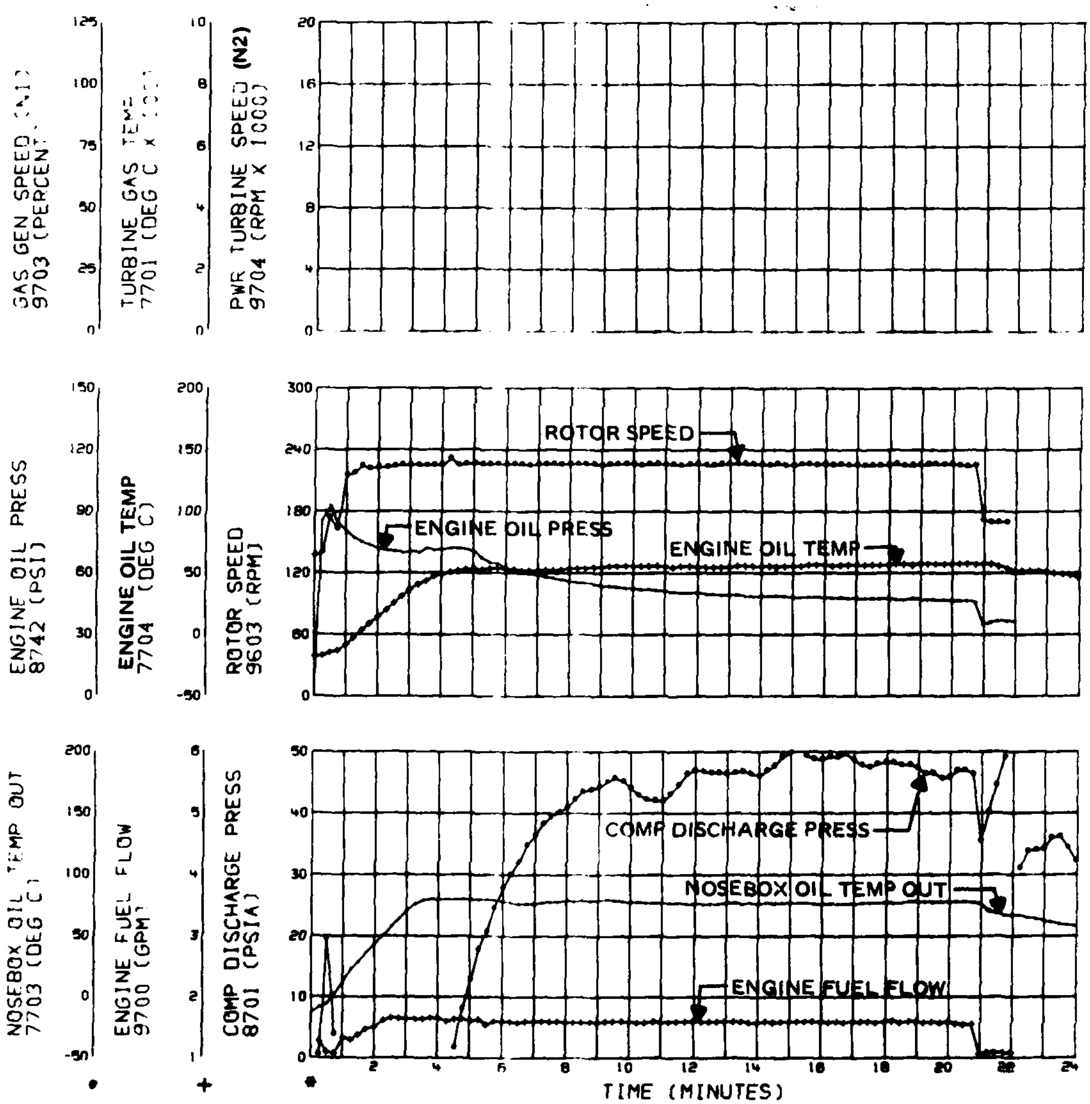


FIGURE 35

NO. 1 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL

2. JP-5 FUEL UTILIZED

3. N_2 AND COMP DISCHARGE PRESSURE INSTRUMENTATION INOPERATIVE

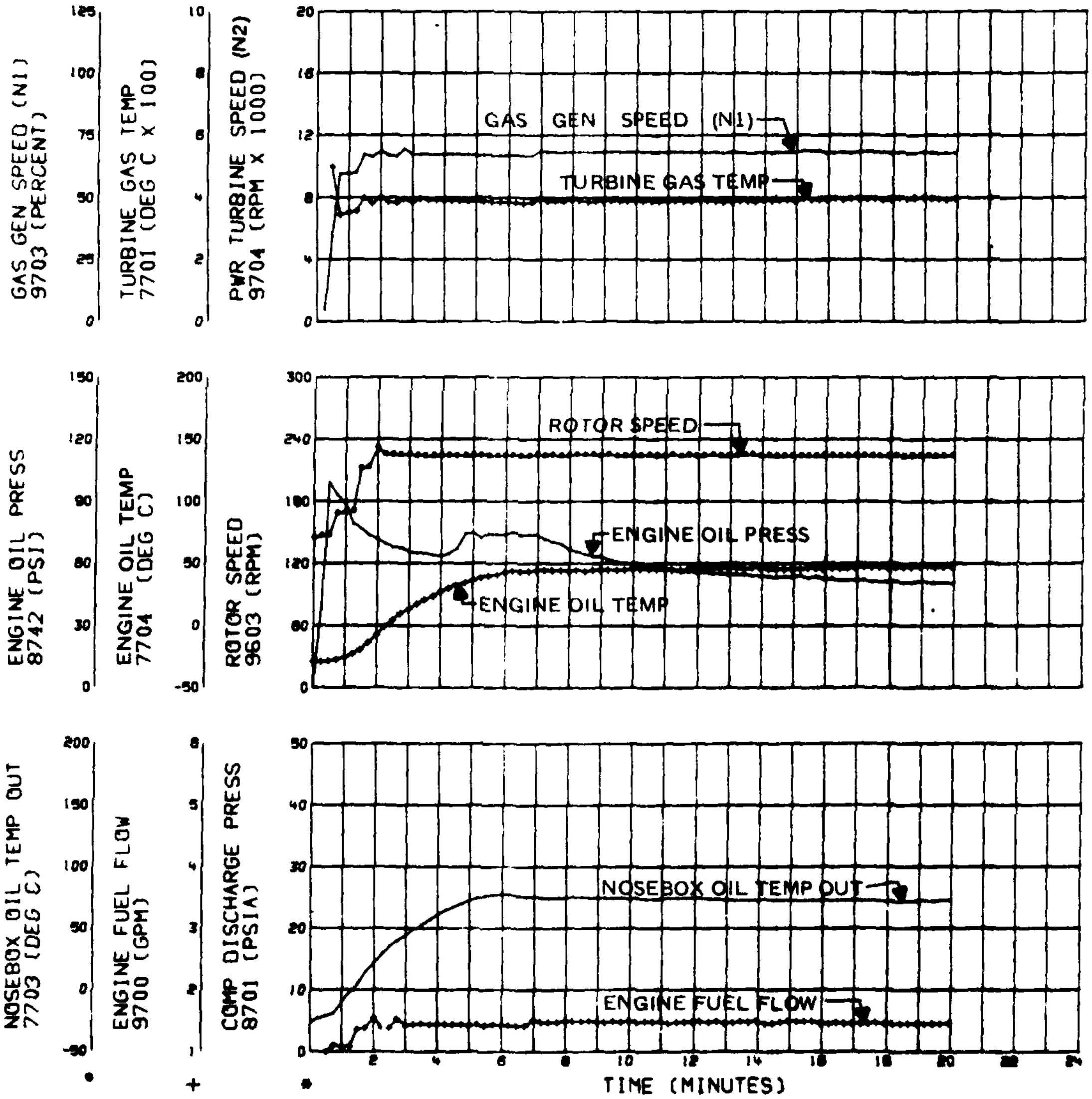


FIGURE 36

NO. 1 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808 OIL

2. JP-4 FUEL UTILIZED

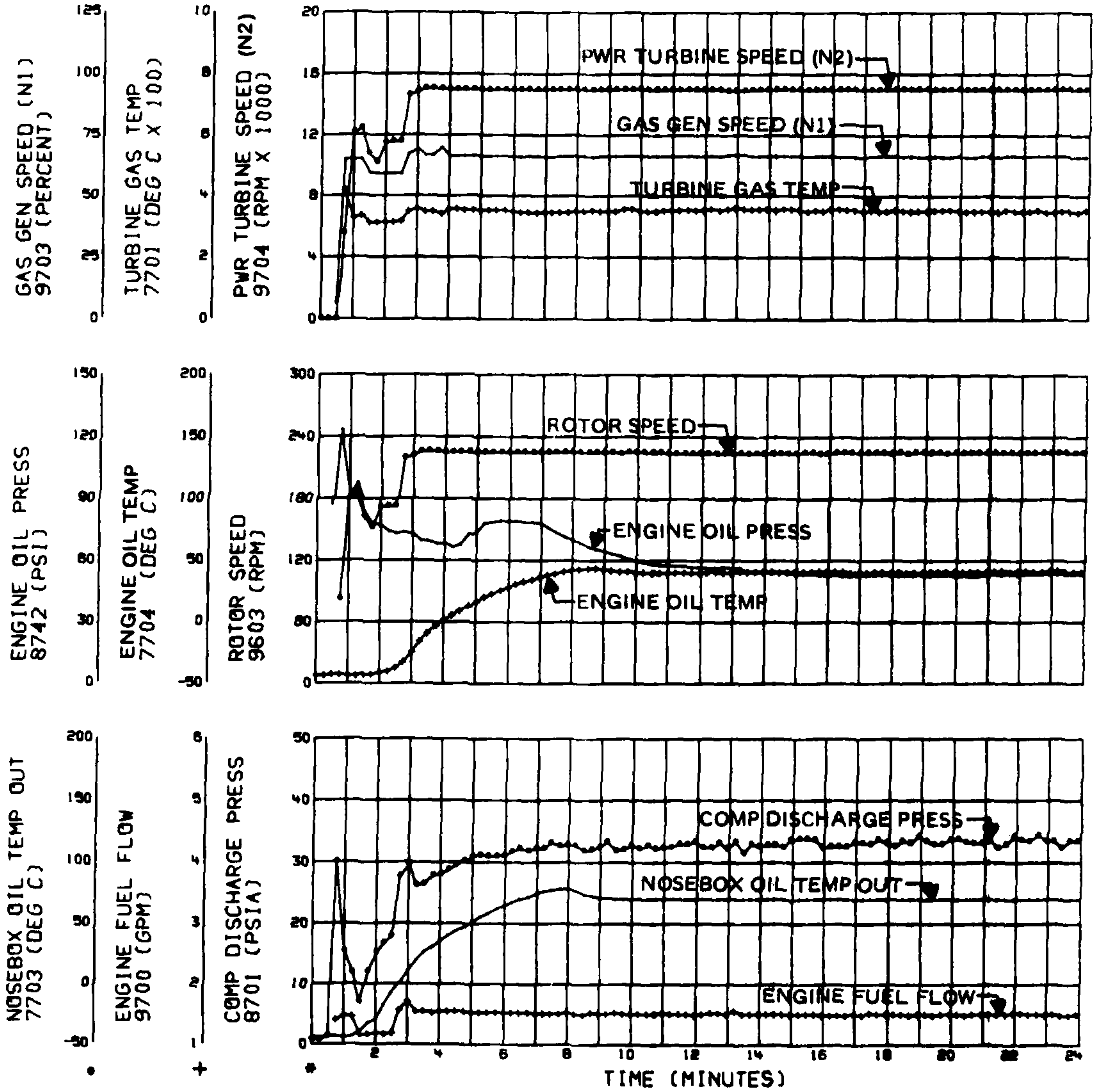


FIGURE 37

NO. 1 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19566

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808 OIL

2. JP-4 FUEL UTILIZED

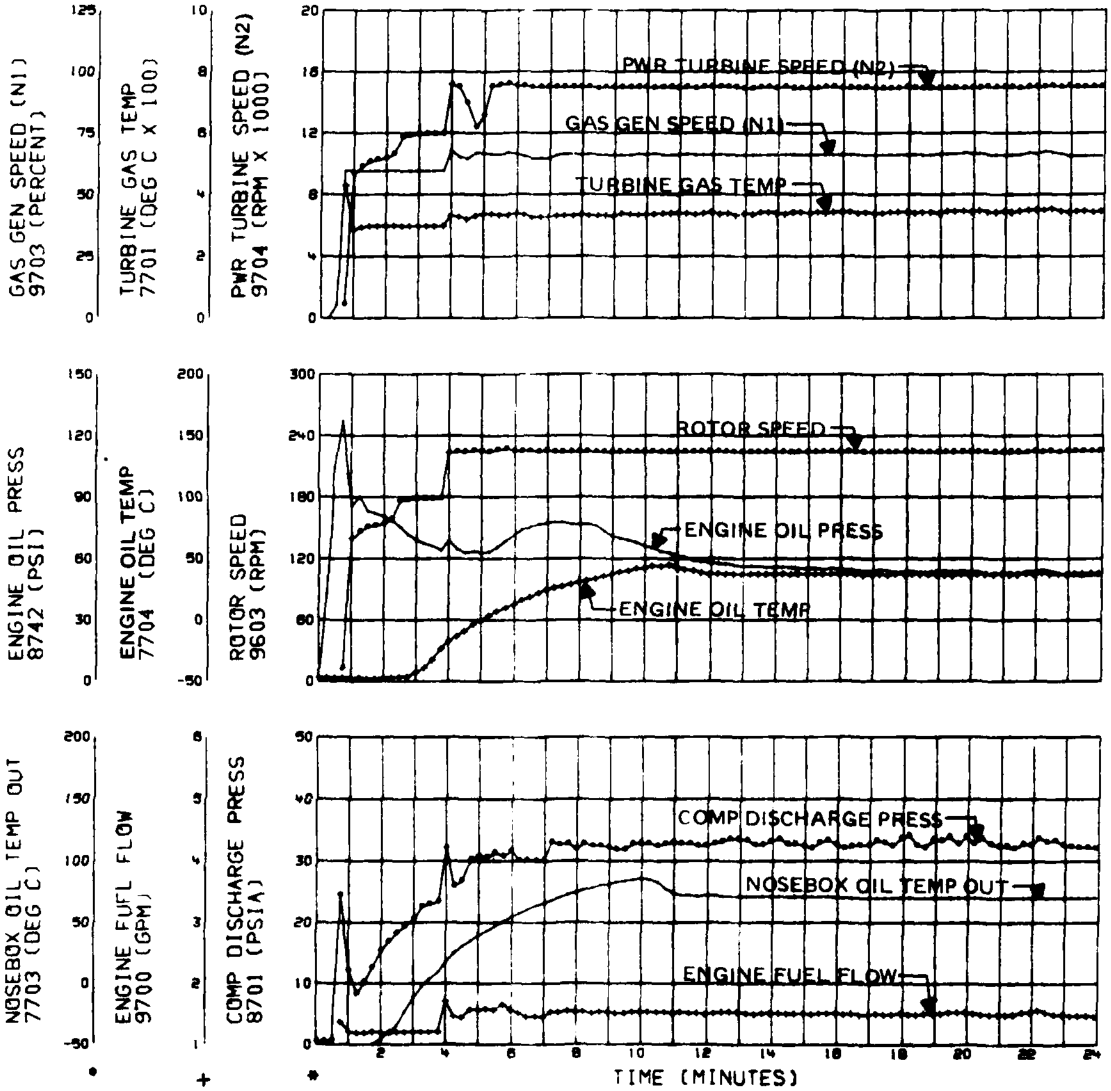


FIGURE 38
NO. 1 ENGINE RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19566
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. JP-5 FUEL UTILIZED

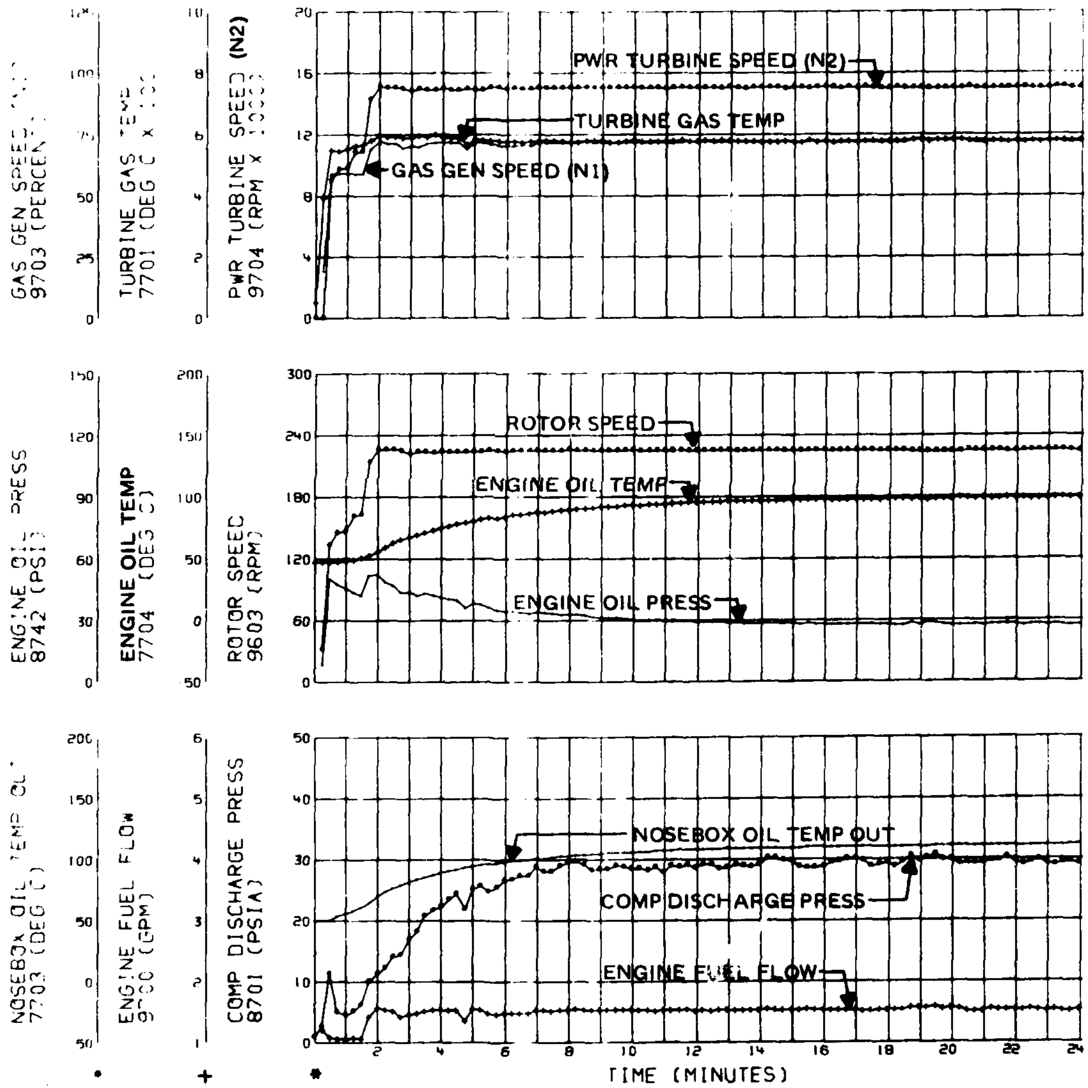


FIGURE 39

NO. 2 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL

2. JP-5 FUEL UTILIZED

3. RUN ACCOMPLISHED SUBSEQUENT TO -65°F TESTING

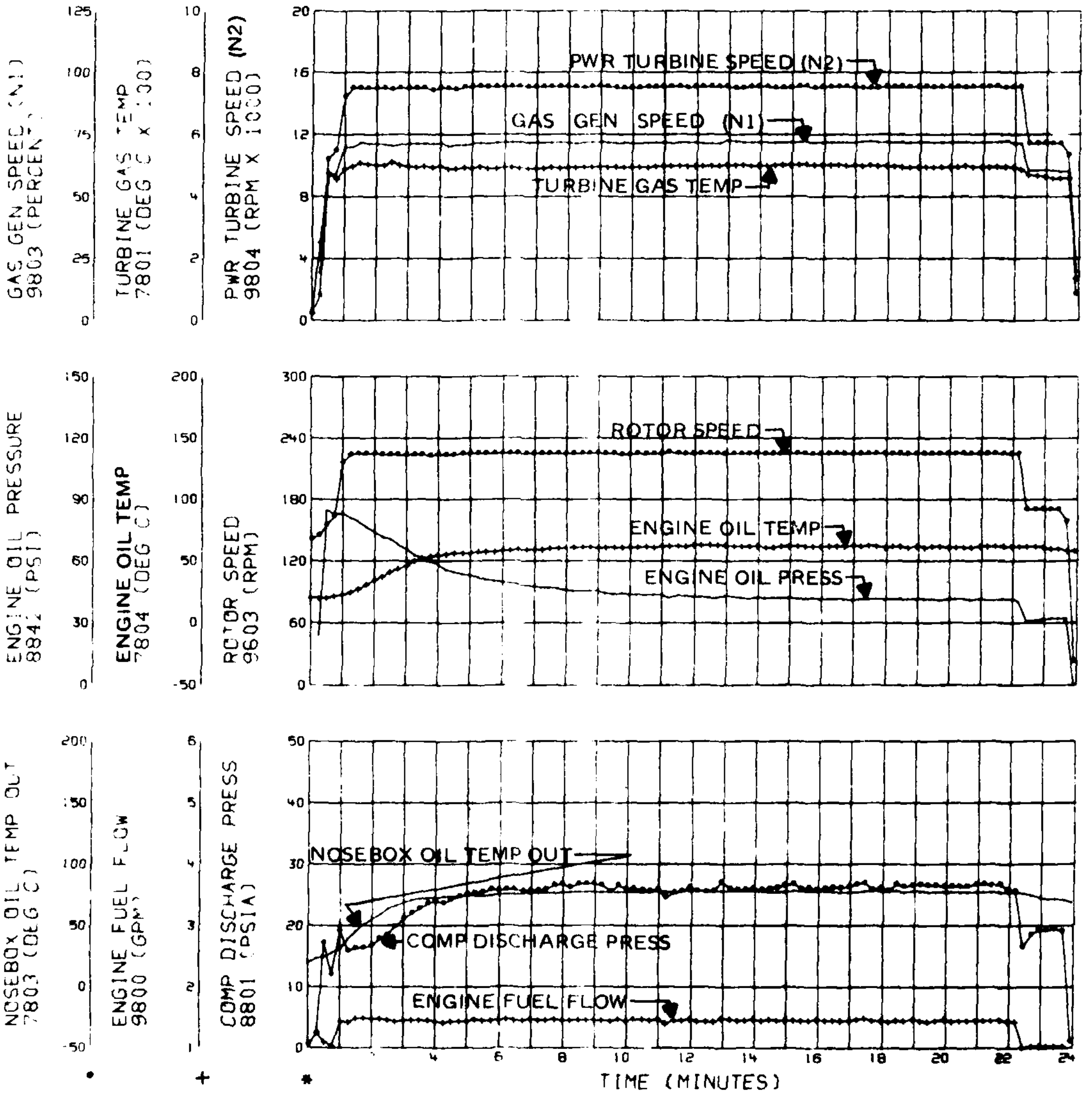


FIGURE 40
NO. 2 ENGINE RUN CHARACTERISTICS
YCH-47D US ARMY S/N 76-8008
T55-L-712 LYCOMING ENGINE S/N LE19296
CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL
2. JP-5 FUEL UTILIZED
3. N_1 INSTRUMENTATION INOPERATIVE

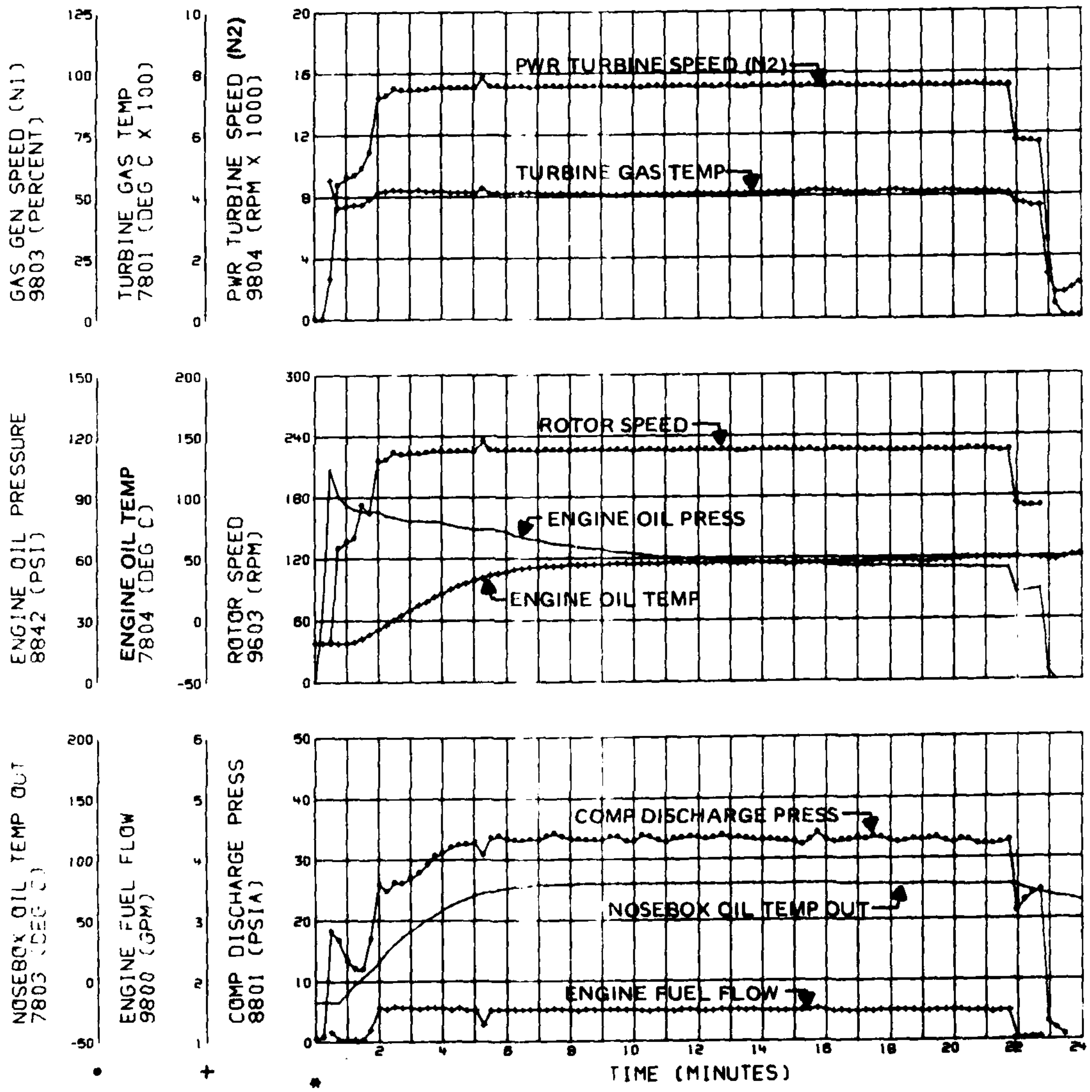


FIGURE 41

NO. 2 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL

2. JP-5 FUEL UTILIZED

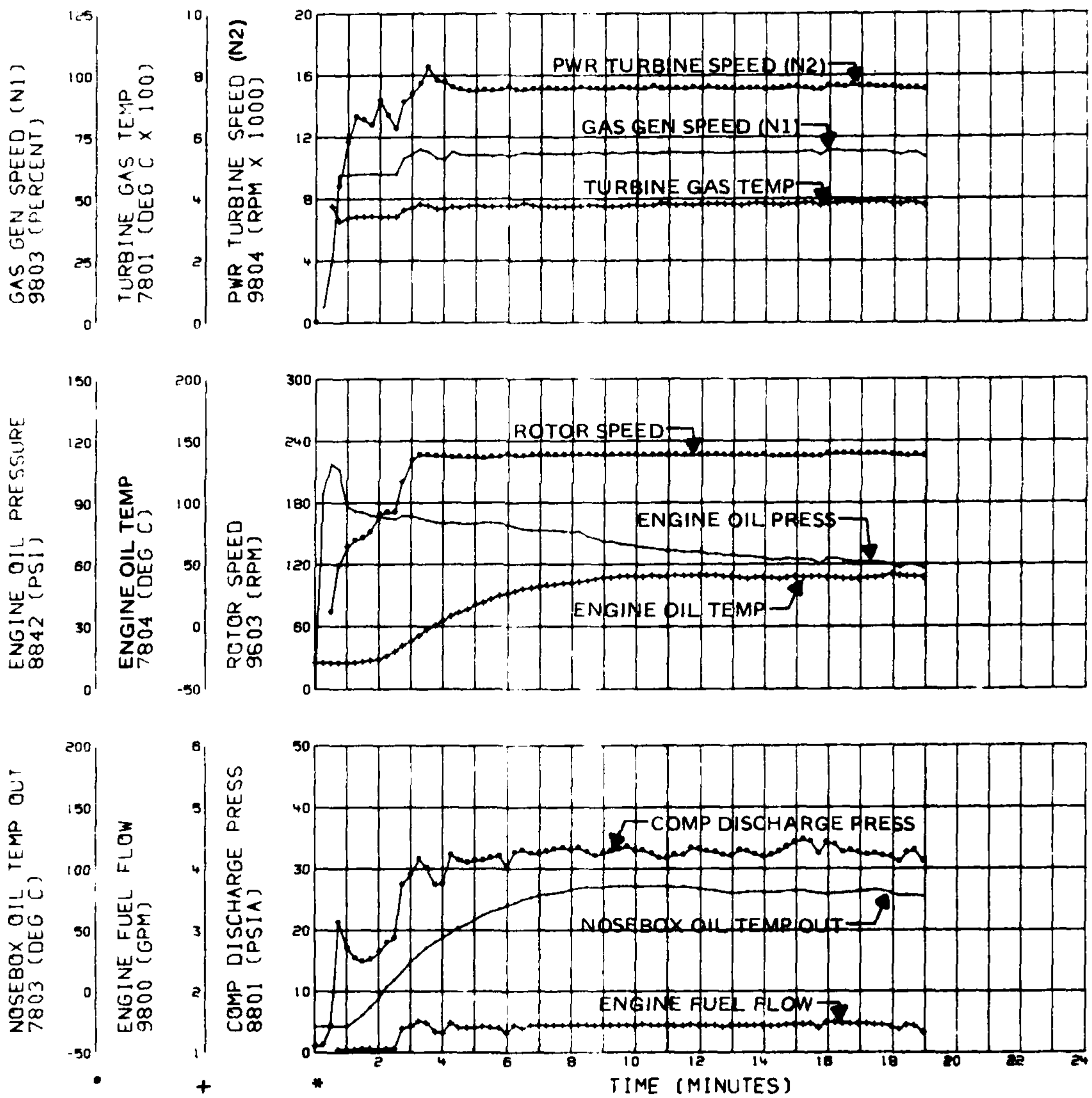


FIGURE 42

NO. 2 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808 OIL

2. JP-4 FUEL UTILIZED

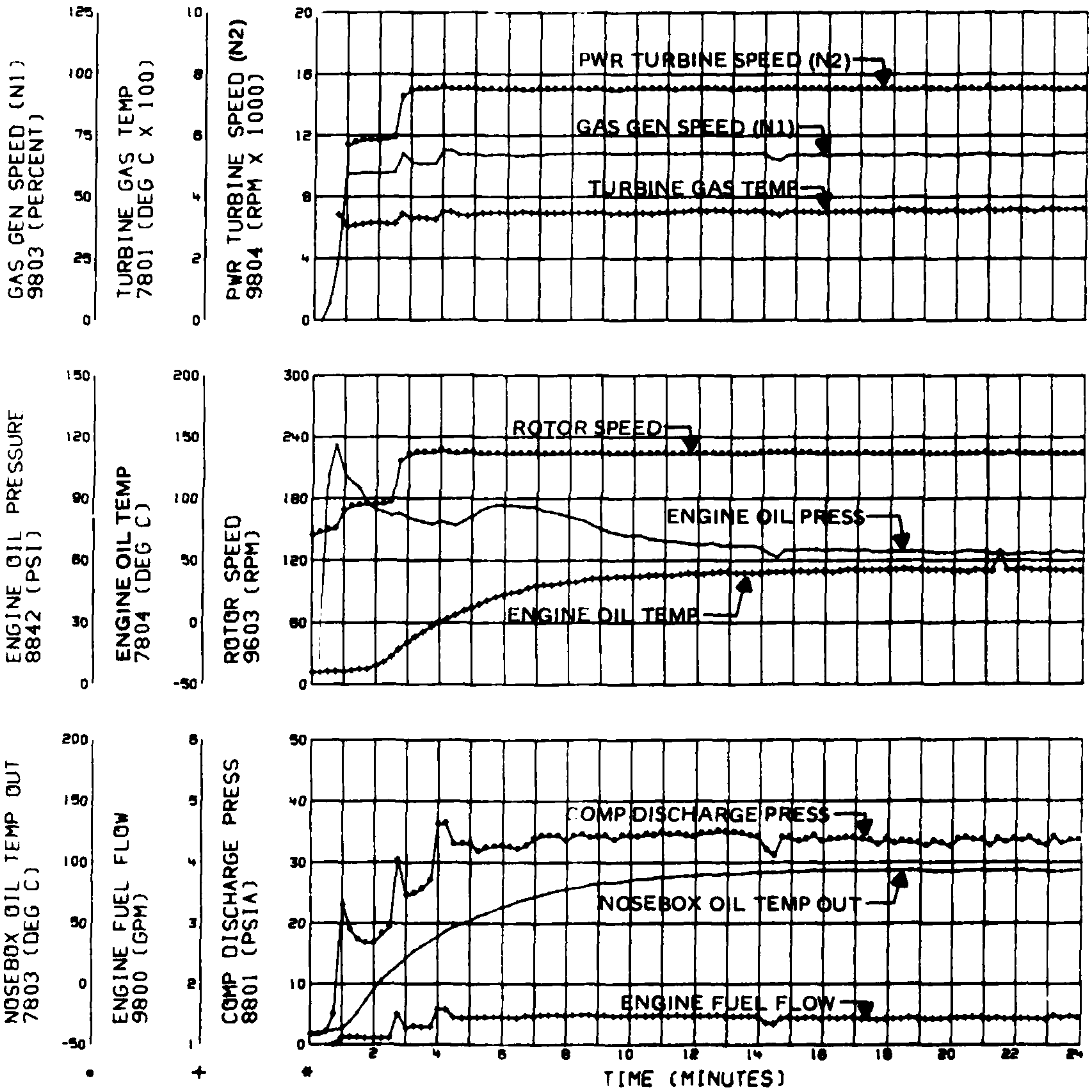


FIGURE 43

NO. 2 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808 OIL

2. JP-4 FUEL UTILIZED

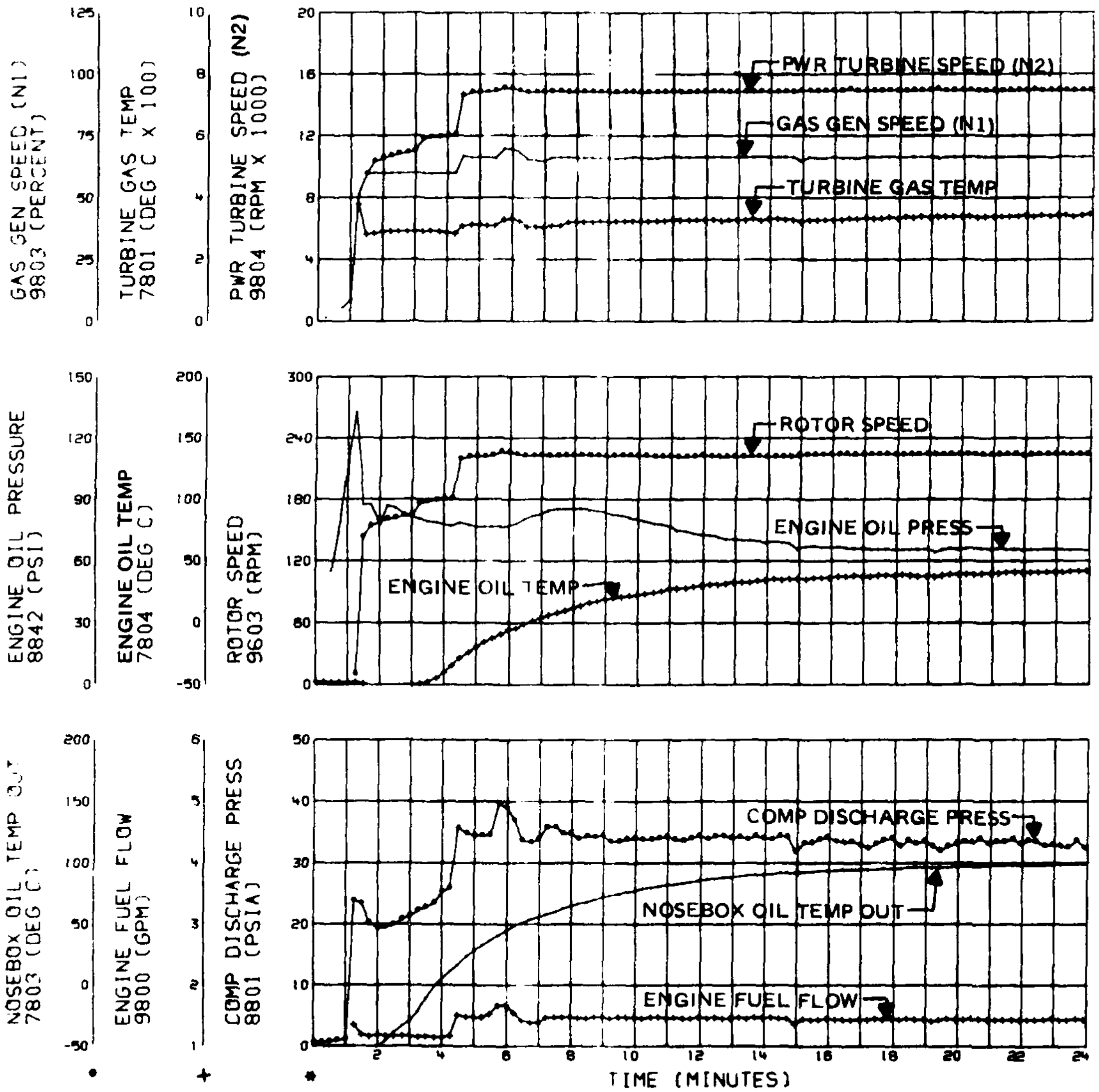


FIGURE 44

NO. 2 ENGINE RUN CHARACTERISTICS

YCH-47D US ARMY S/N 76-8008

T55-L-712 LYCOMING ENGINE S/N LE19296

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699 OIL

2. JP-5 FUEL UTILIZED

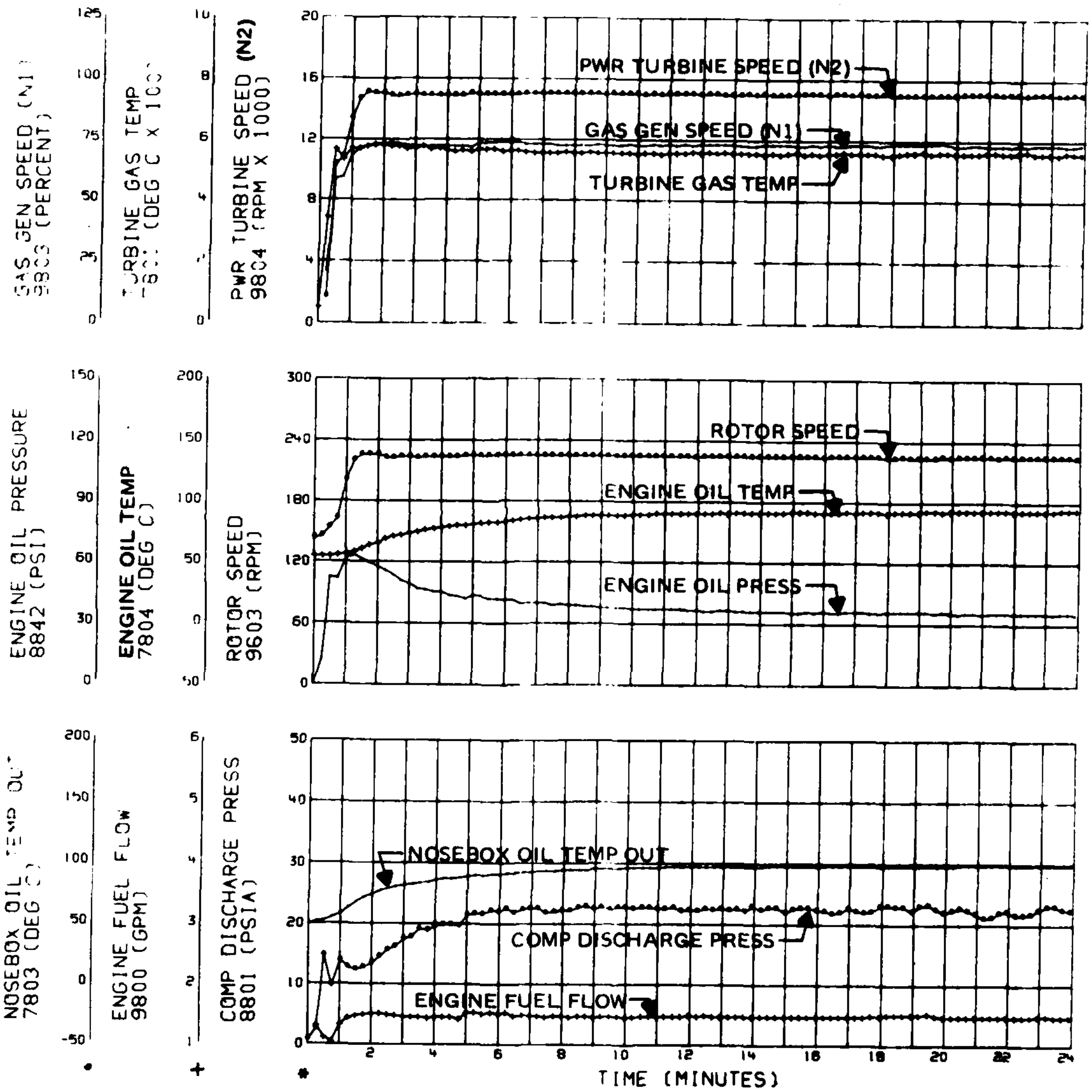


FIGURE 45
CABIN TEMPERATURE SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. CABIN AND COCKPIT AIR ON
2. COCKPIT DEFROSTERS OFF
3. RUN ACCOMPLISHED SUBSEQUENT TO -65°F TESTING

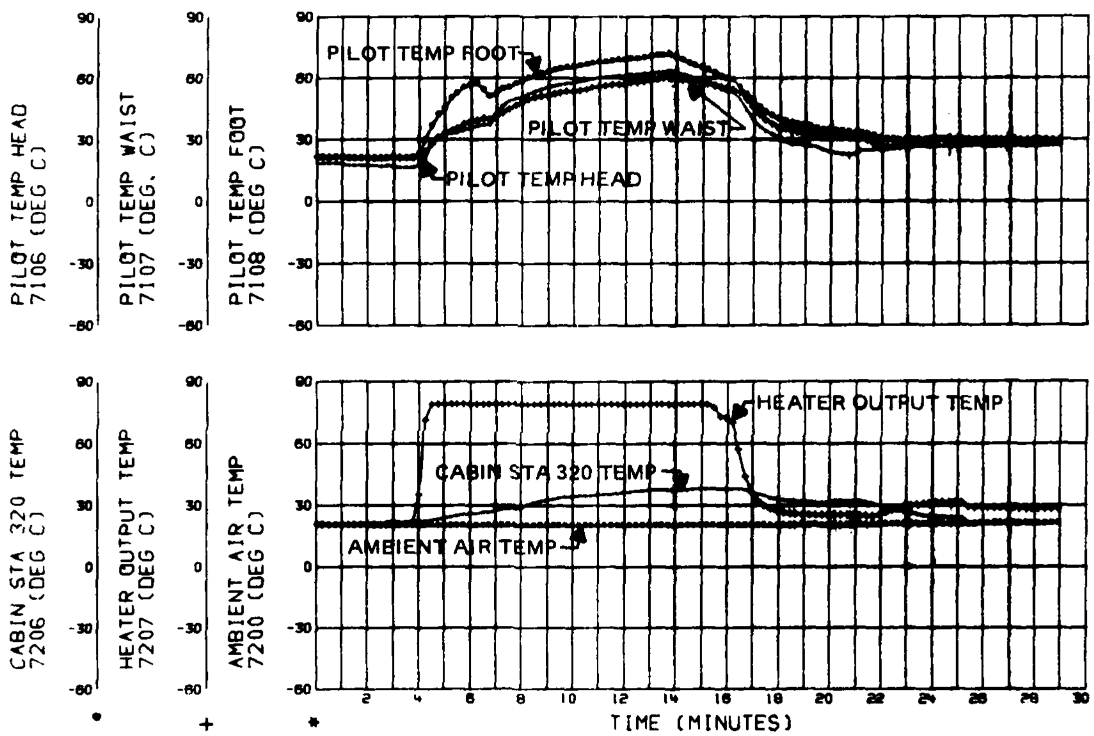


FIGURE 46
CABIN TEMPERATURE SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. CABIN AIR ON, COCKPIT AIR OFF
2. COCKPIT DEFROSTERS OFF
3. RUN ACCOMPLISHED SUBSEQUENT TO -65°F TESTING

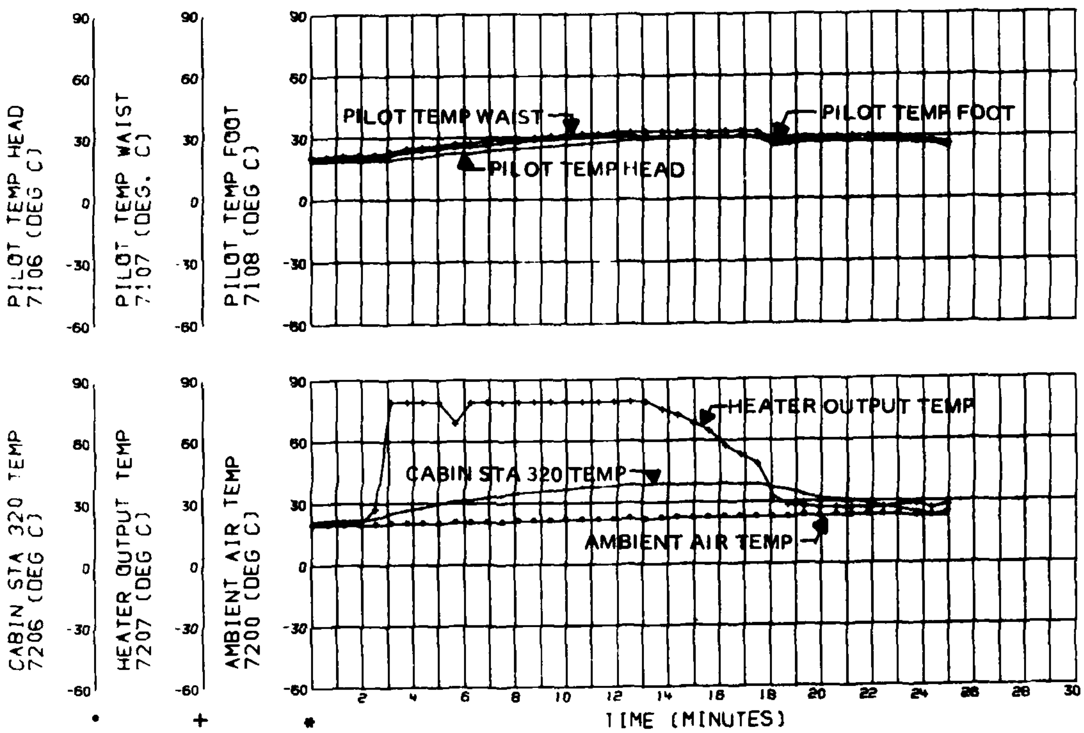


FIGURE 47
CABIN TEMPERATURE SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES: 1. CABIN AND COCKPIT AIR ON
2. COCKPIT DEFROSTERS OFF

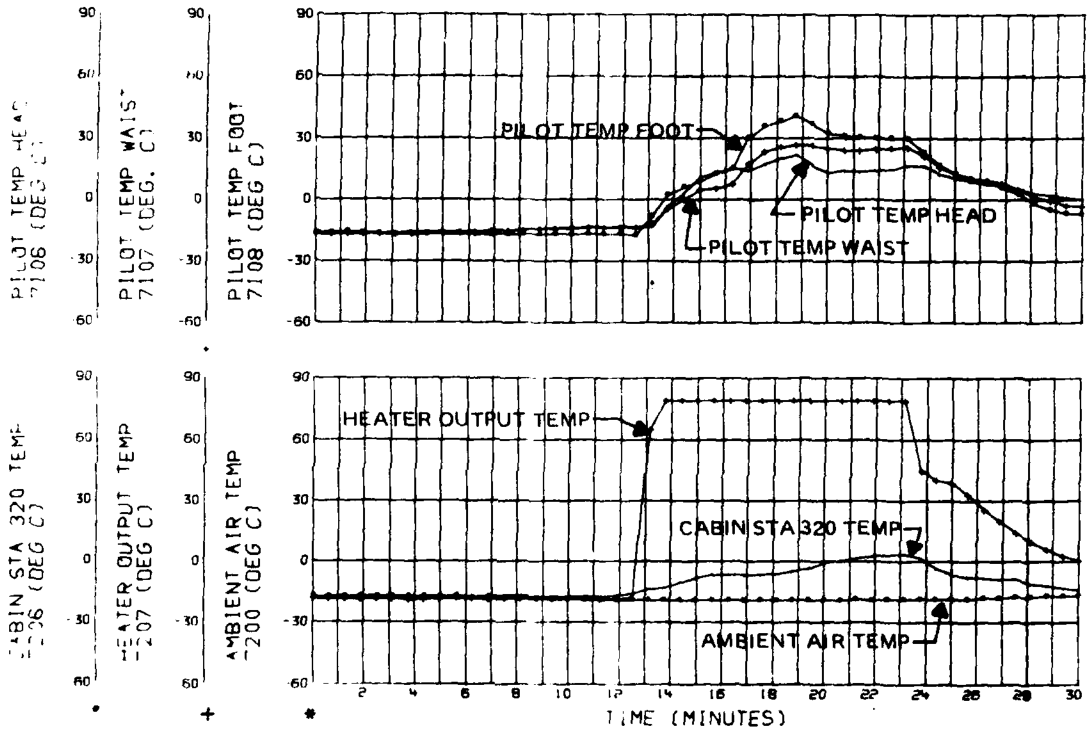


FIGURE 48
CABIN TEMPERATURE SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES: 1. CABIN AND COCKPIT AIR ON
2. COCKPIT DEFROSTERS OFF

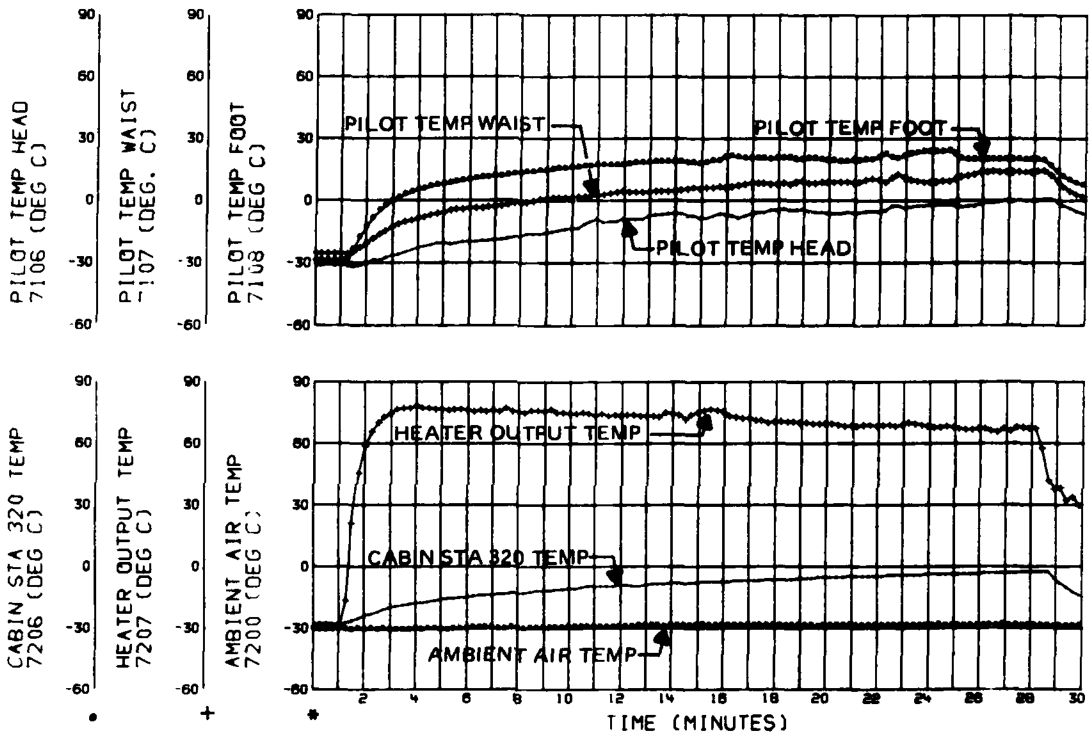


FIGURE 49
CABIN TEMPERATURE SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. CABIN AND COCKPIT AIR ON
2. COCKPIT DEFROSTERS OFF

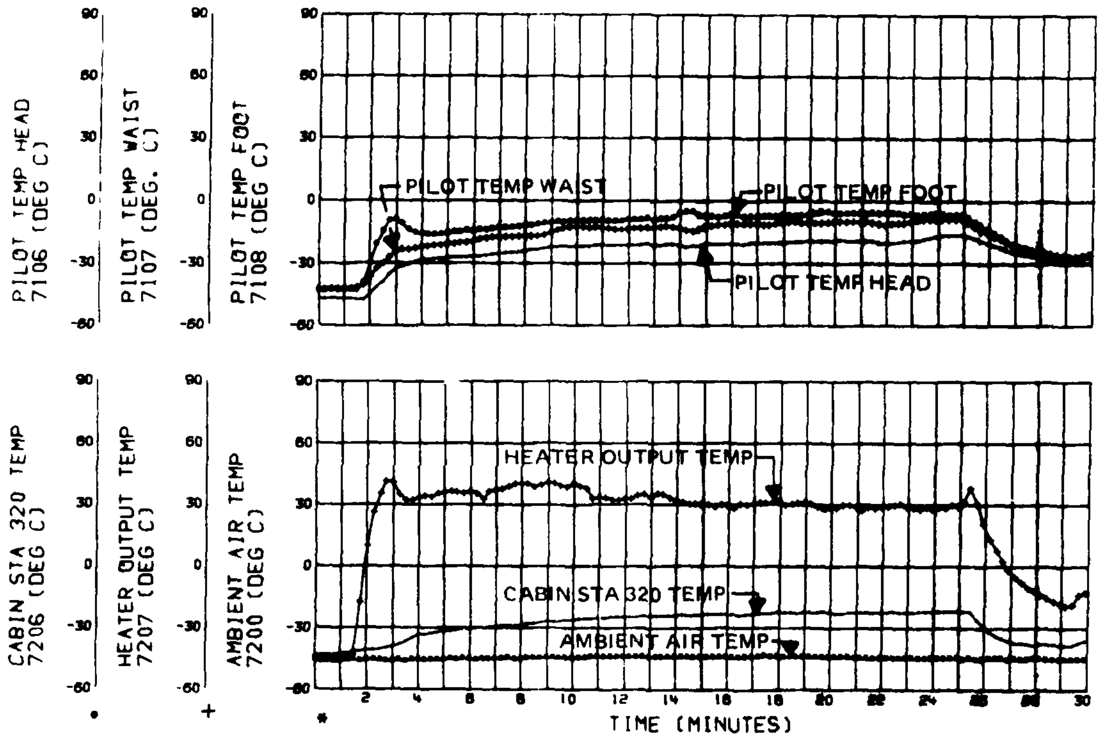


FIGURE 50
CABIN TEMPERATURE SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. CABIN AND COCKPIT AIR ON
2. COCKPIT DEFROSTERS OFF

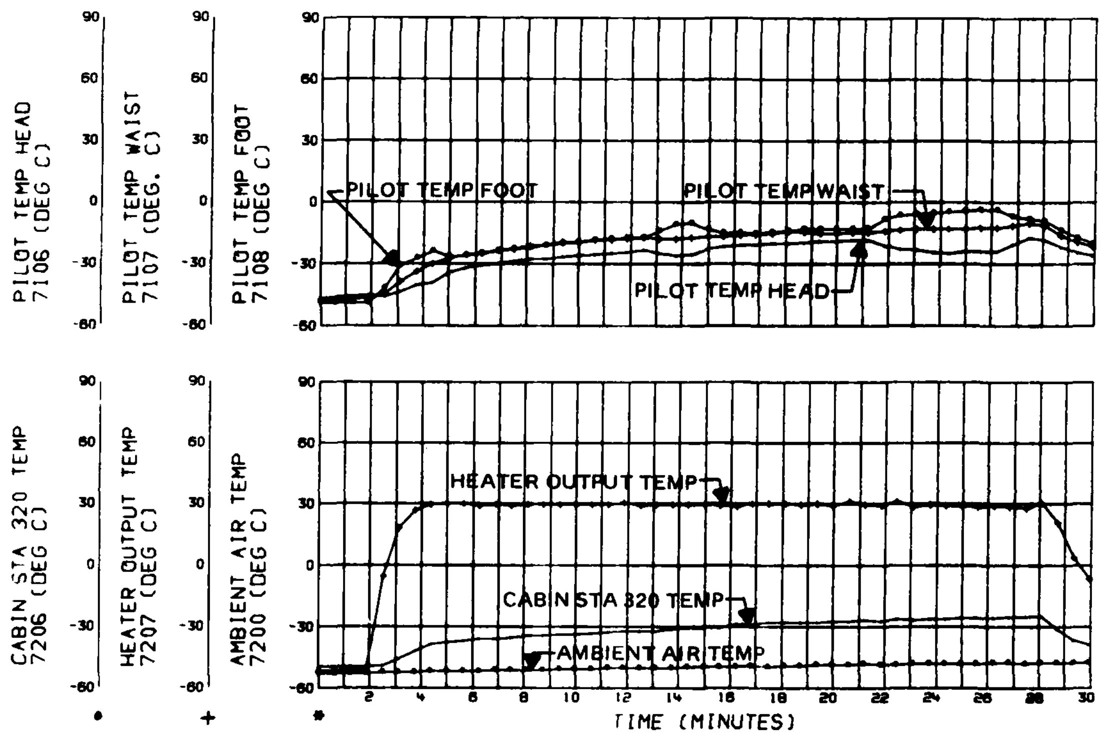


FIGURE 51
ELECTRICAL SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. ELECTRICAL LOAD INCREASED BY LOAD BANKS TO APPROXIMATELY 30 KVA

2. SIMULATED GENERATOR 1 FAILURE AT 40 SECONDS RESULTS IN INCREASED LOAD PICKED UP BY GENERATOR 2

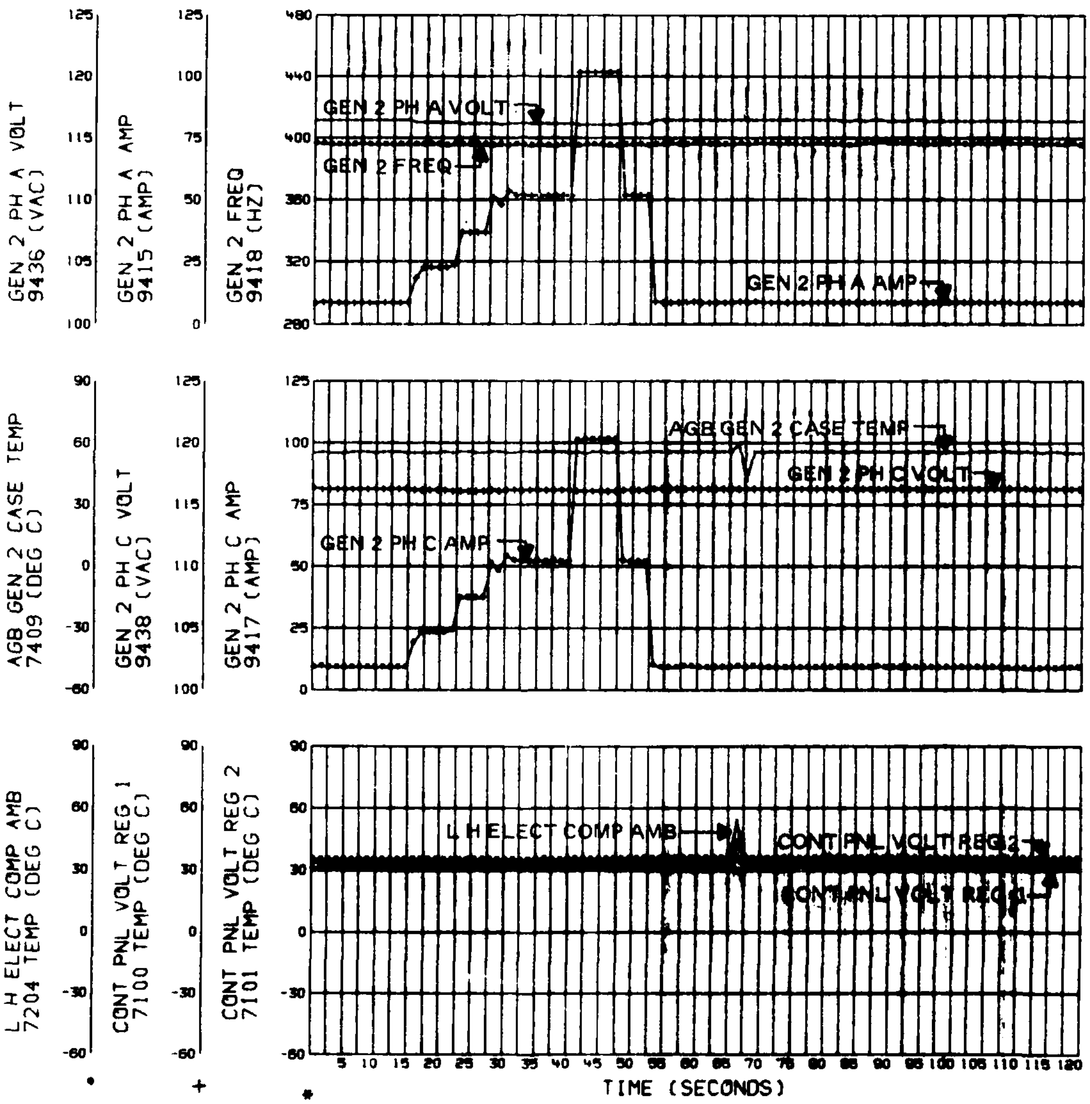


FIGURE 52
ELECTRICAL SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. ELECTRICAL LOAD INCREASED BY LOAD BANKS TO APPROXIMATELY 30 KVA
2. SIMULATED GENERATOR 1 FAILURE AT 96 SECONDS RESULTS IN INCREASED LOAD PICKED UP BY GENERATOR 2
3. NO. 1 GENERATOR FREQUENCY PRESENTED

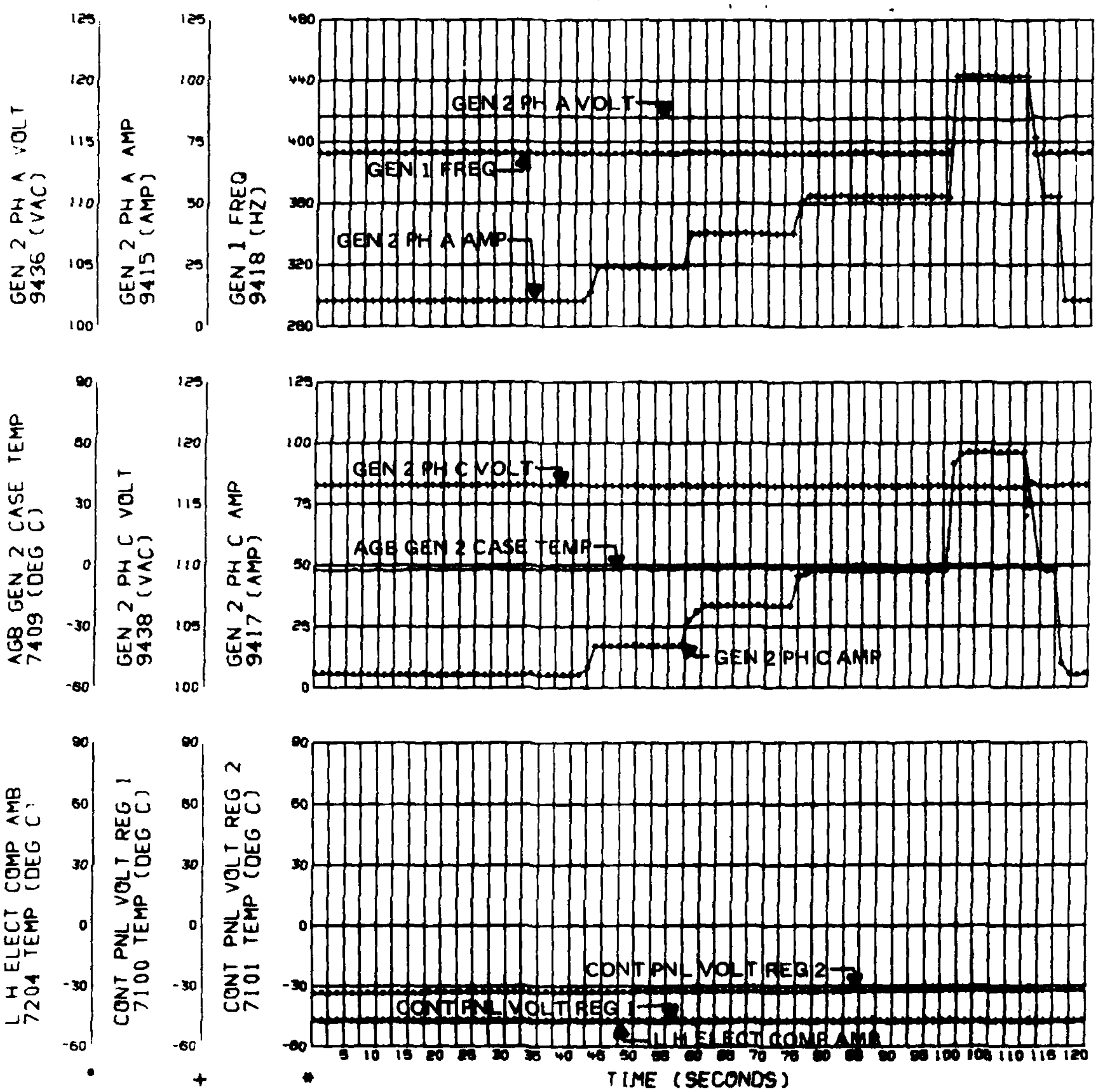


FIGURE 53

ELECTRICAL SYSTEM SURVEY

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. ELECTRICAL LOAD INCREASED BY LOAD BANKS TO APPROXIMATELY 30 KVA
2. SIMULATED GENERATOR 1 FAILURE AT 45 SECONDS RESULTS IN INCREASED LOAD PICKED UP BY GENERATOR 2

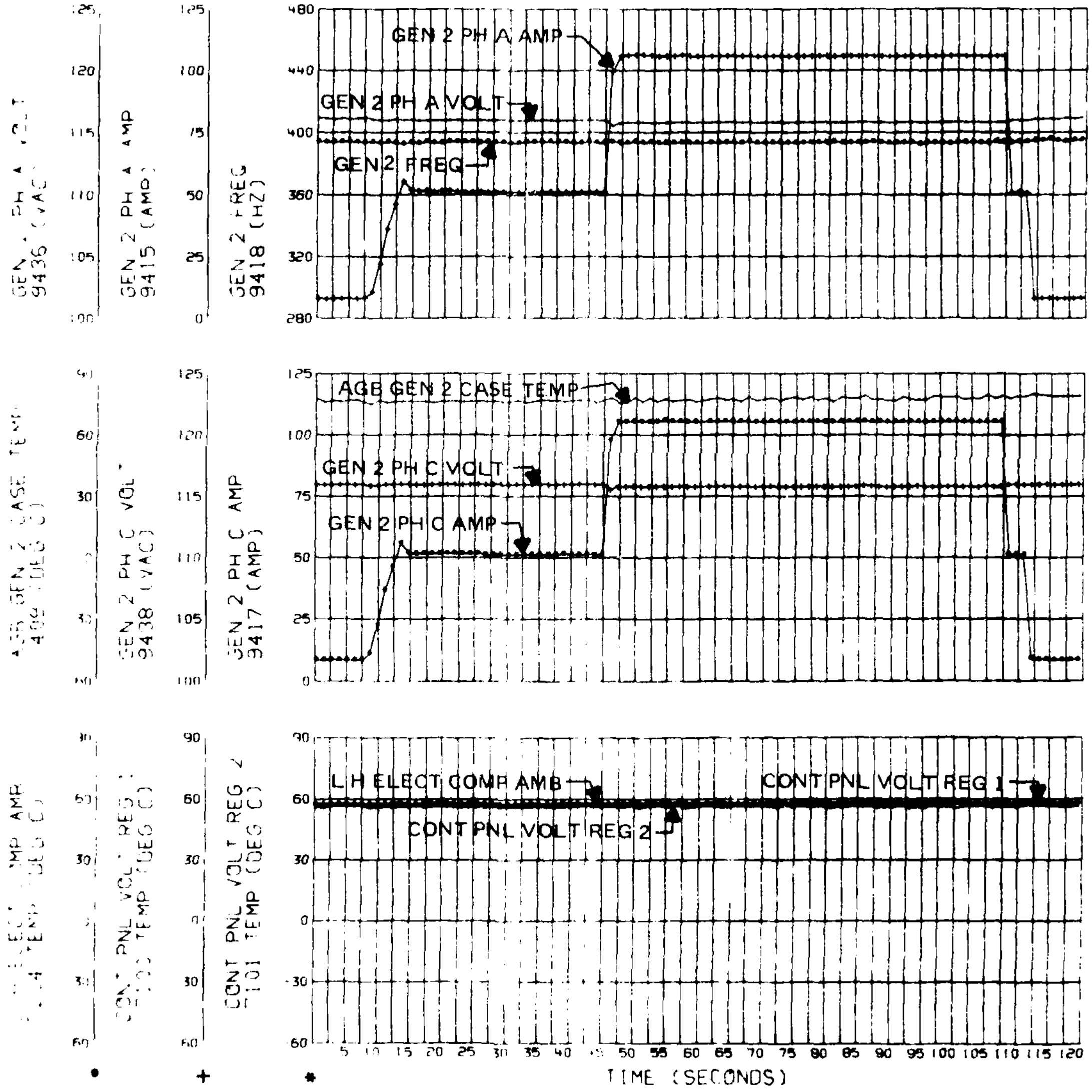


FIGURE 54

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. PHASE PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

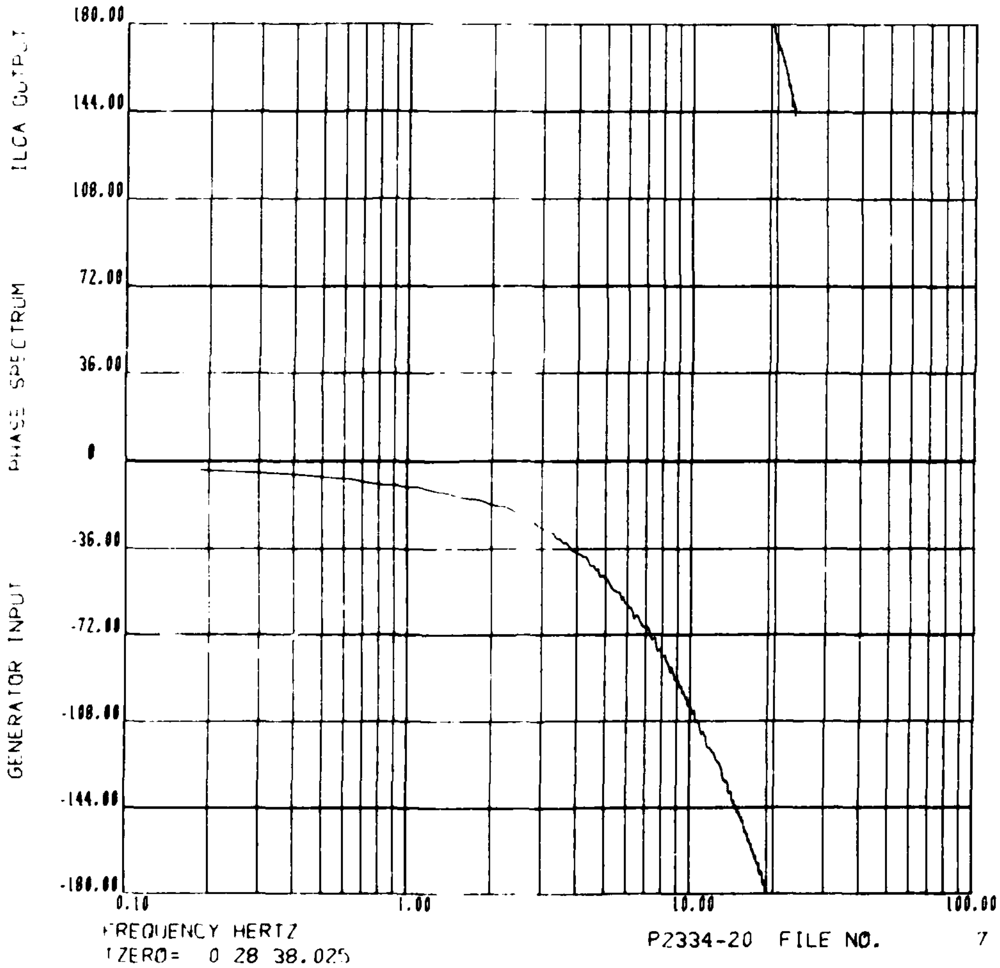


FIGURE 55

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. BODE PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

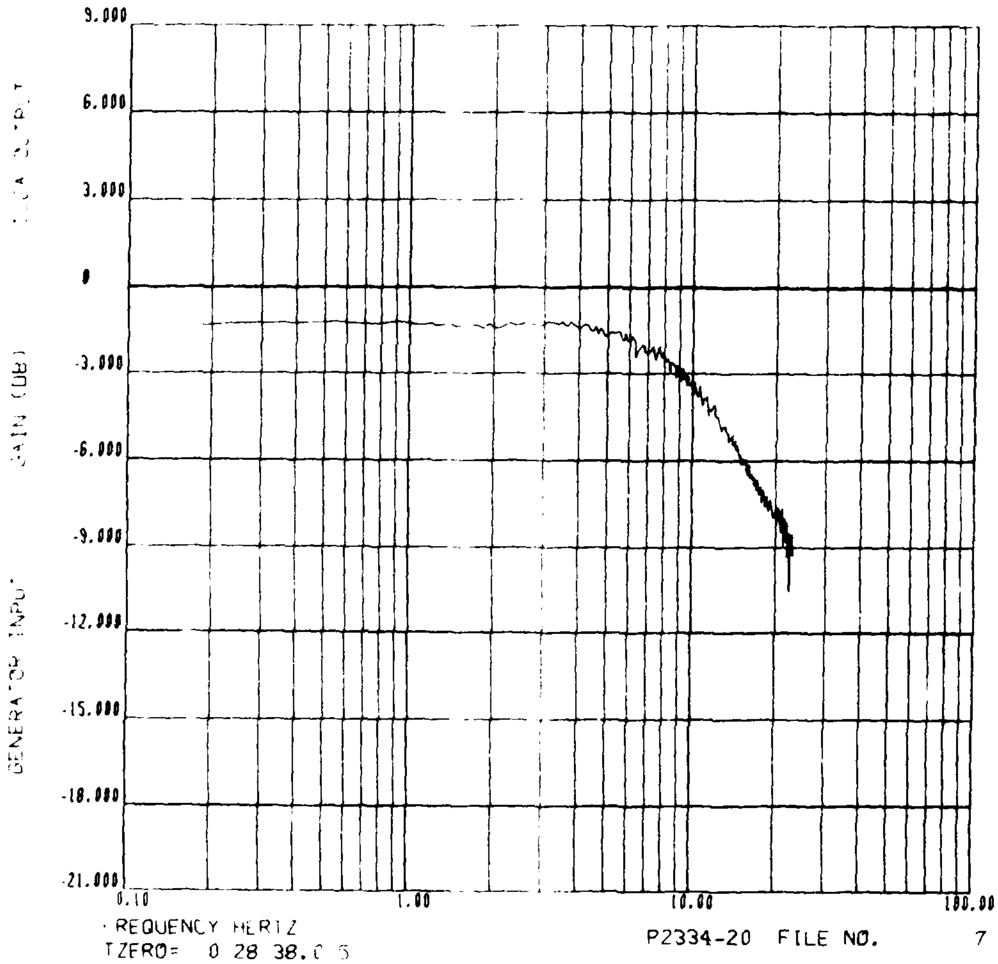


FIGURE 56

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. PHASE PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

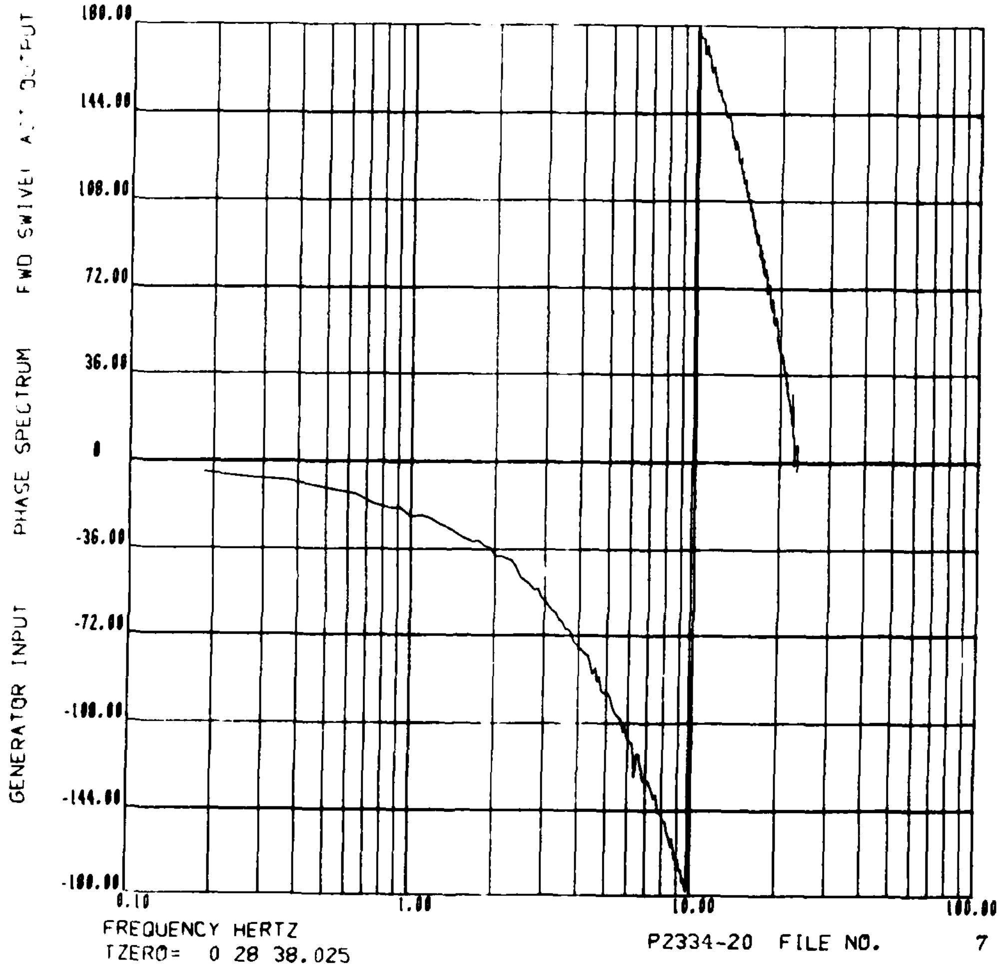


FIGURE 57

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. BODE PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

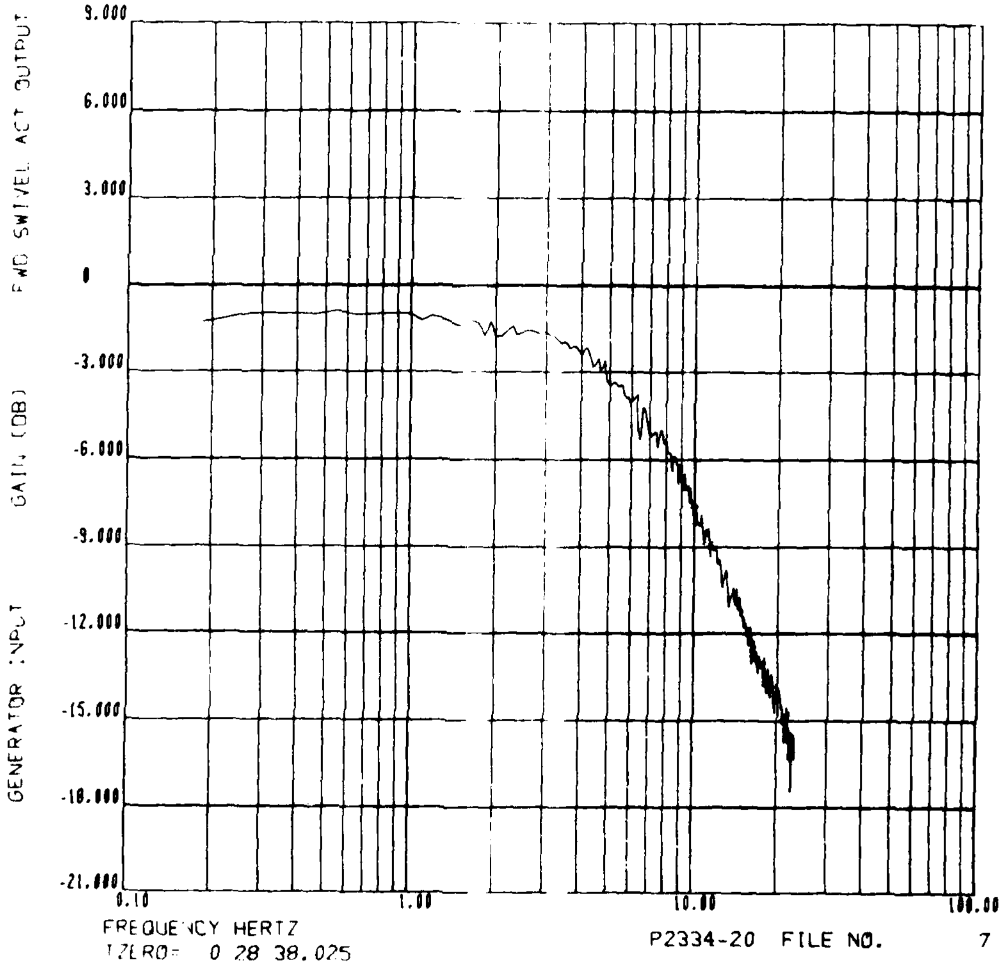


FIGURE 58

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. PHASE PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

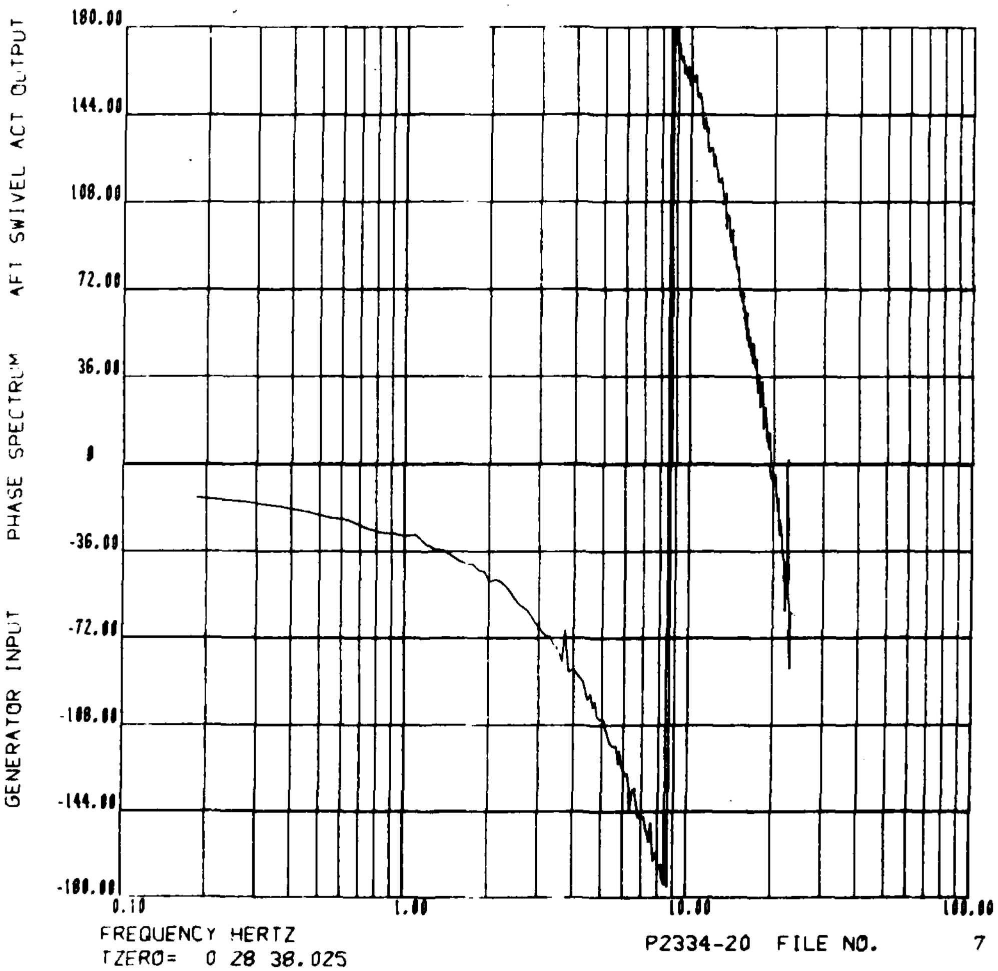


FIGURE 59
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. BODE PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

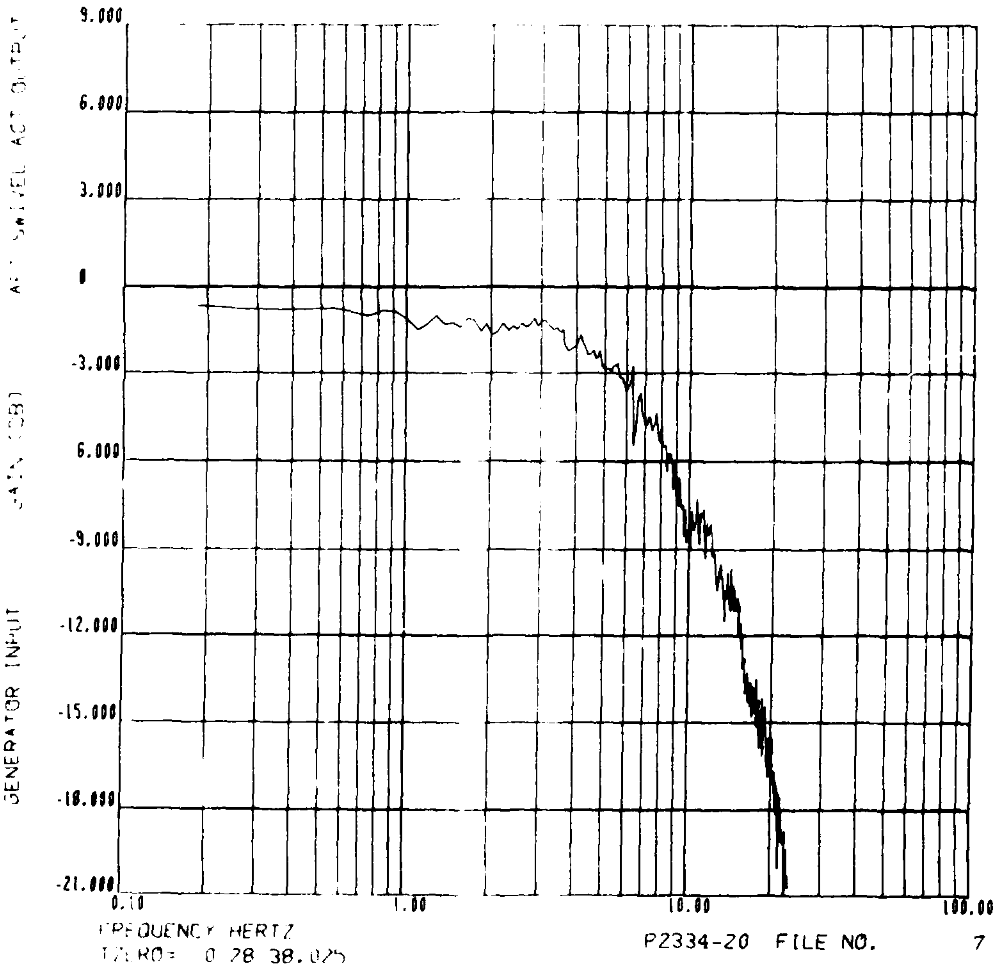


FIGURE 60

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. PHASE PLOT - ILCA INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

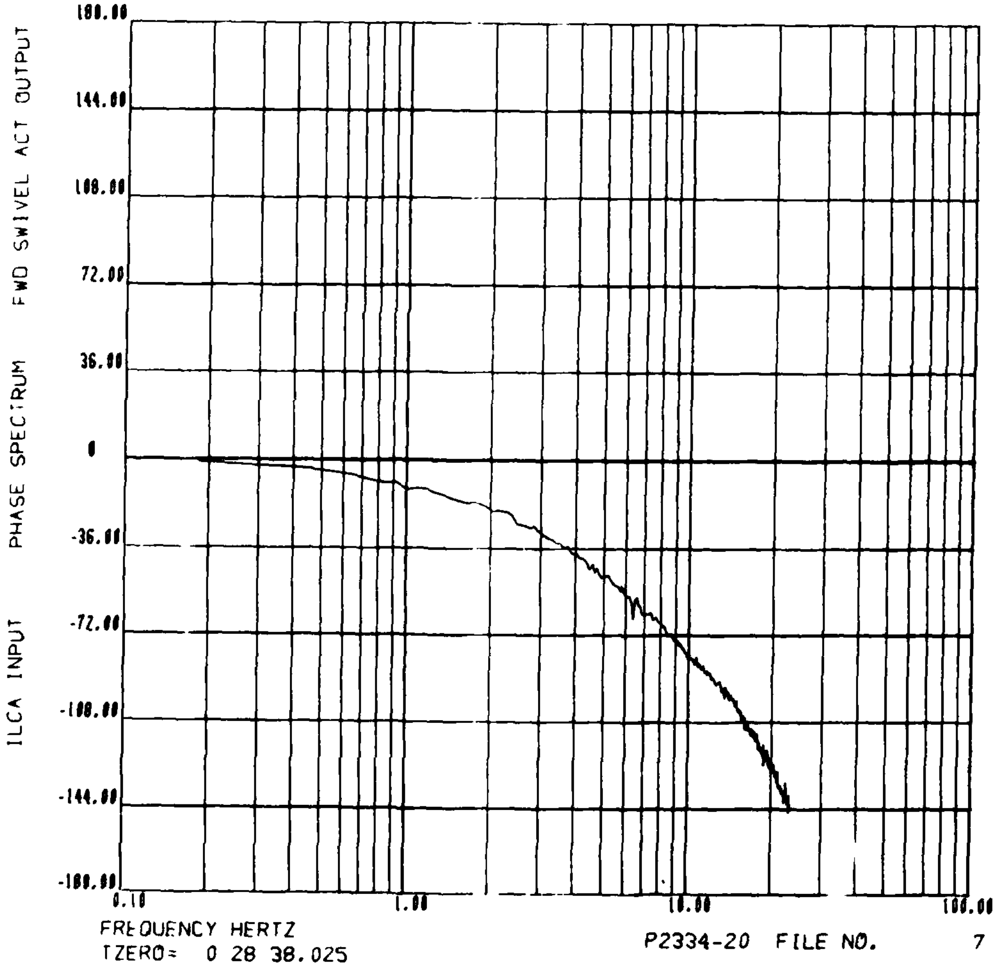


FIGURE 61
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. BODE PLOT - ILCA INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

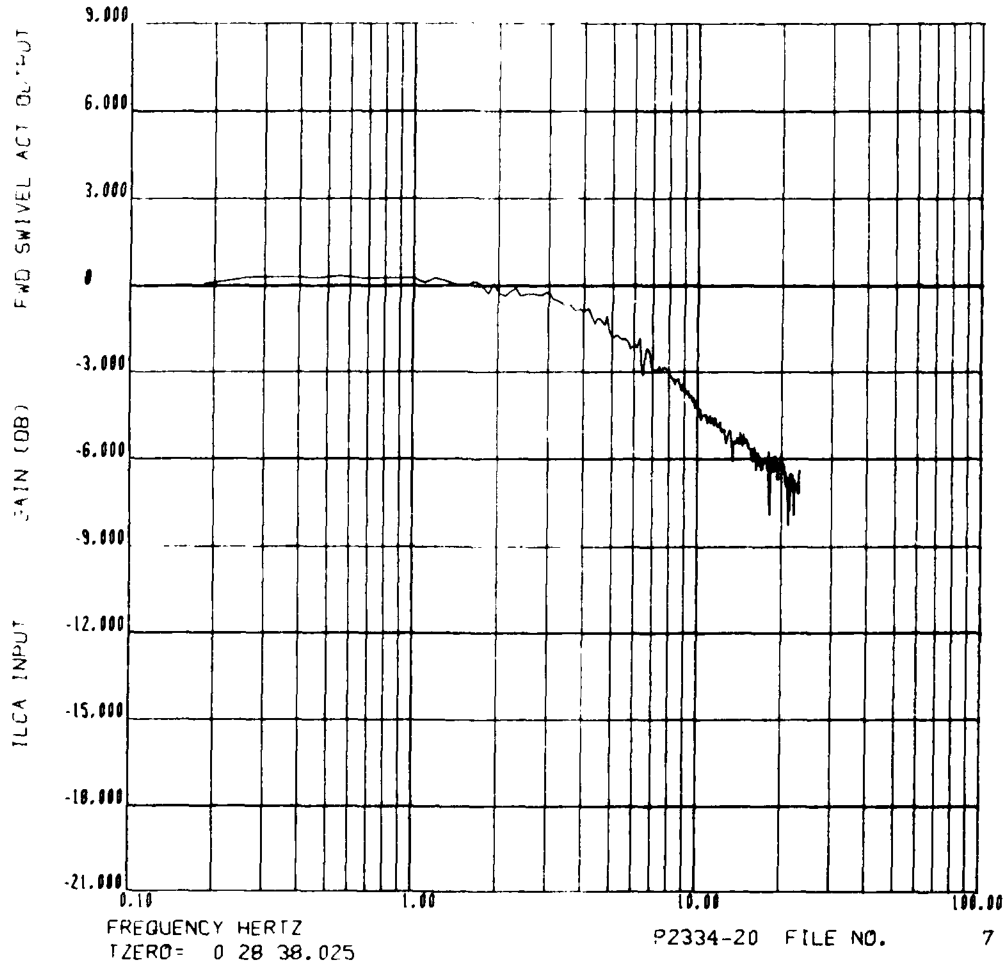


FIGURE 62
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. PHASE PLOT - ILCA INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

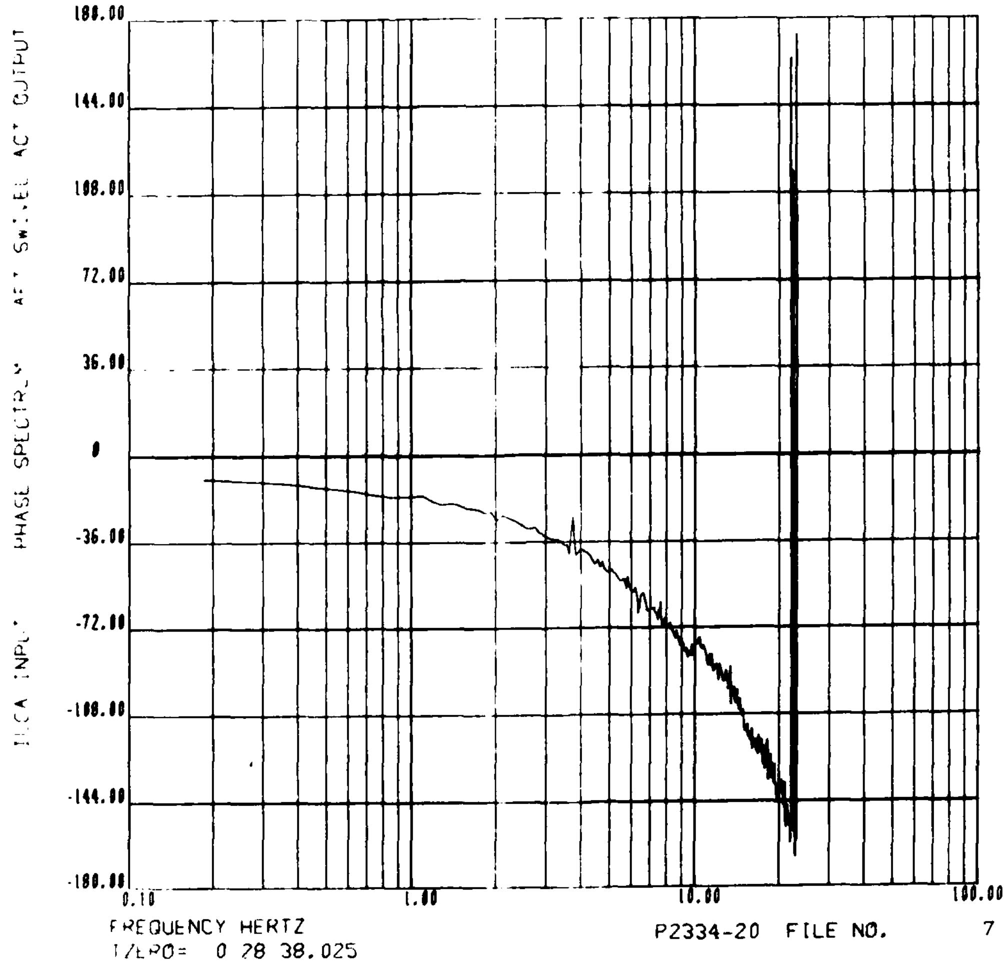


FIGURE 63

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. BODE PLOT - ILCA INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
4. TIME SINCE ENGINE START - 11 MINUTES

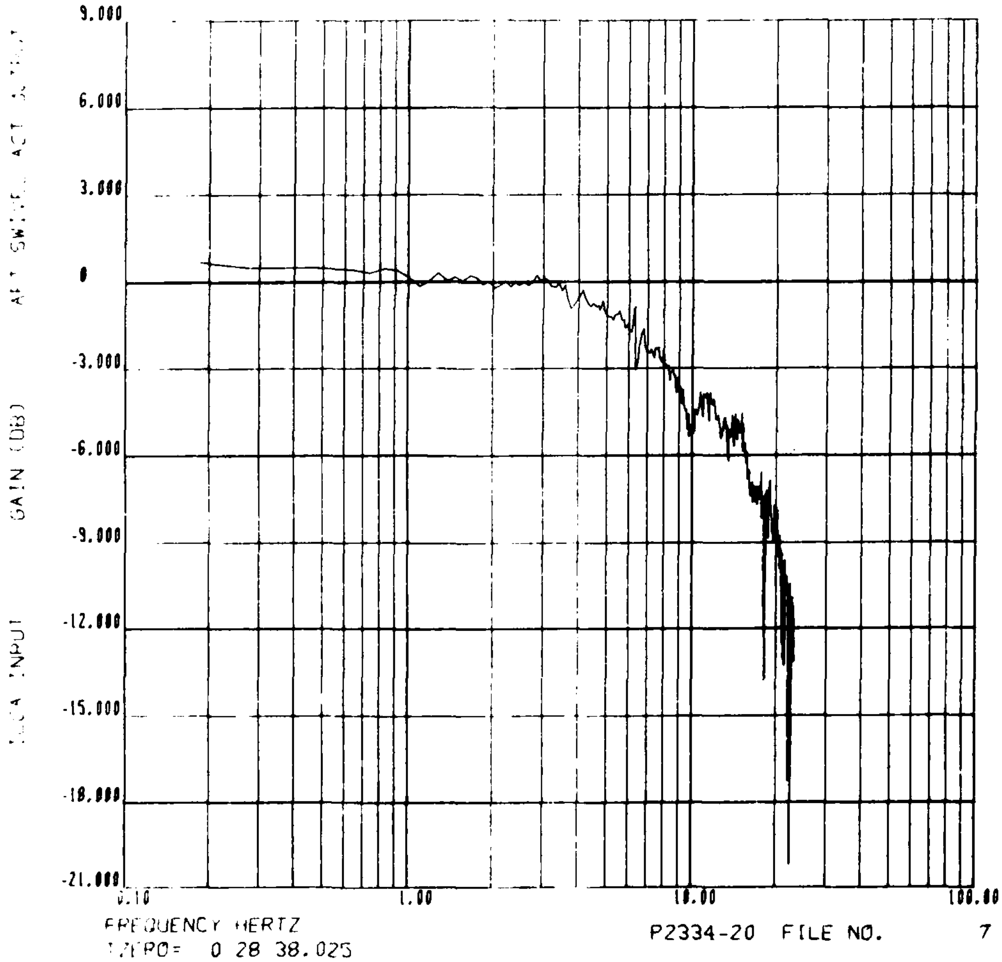
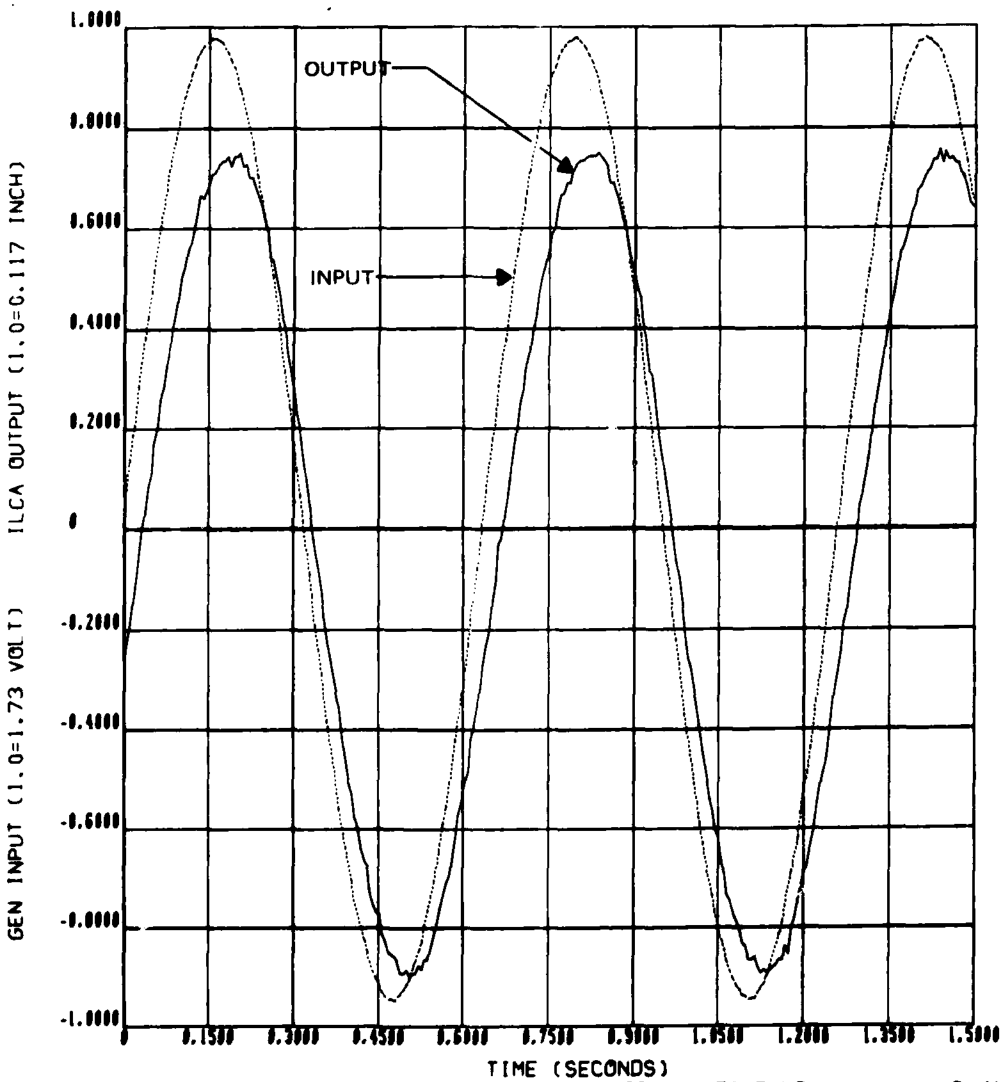


FIGURE 64
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

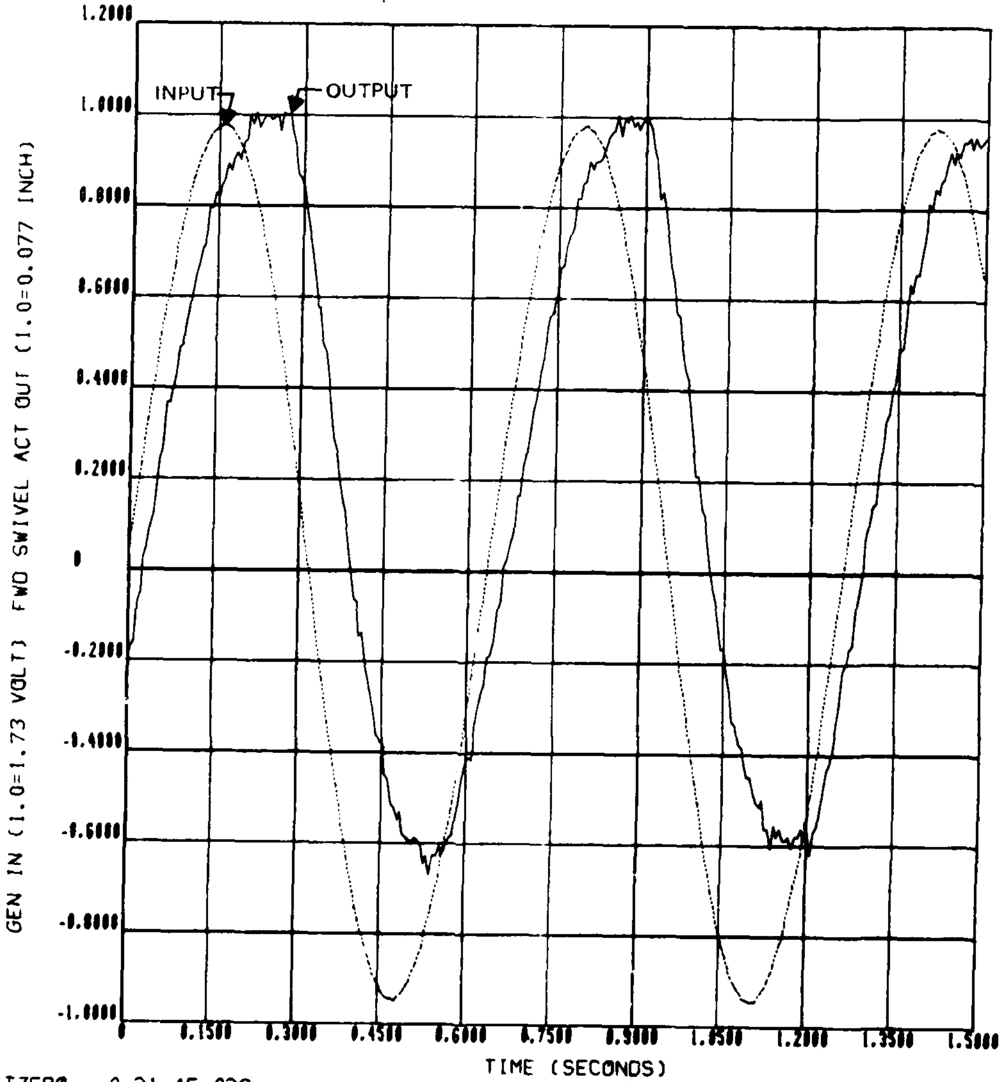
NOTES: 1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈ 1.6 Hz
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C
OUT -27° C
5. TIME SINCE ENGINE START - 11 MINUTES



TZERO 0 31 45.038 P2340 FILE NO. 3 AND 1

FIGURE 65
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈ 1.6 Hz
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
5. TIME SINCE ENGINE START - 11 MINUTES



TZERO 0 31 45.038 P2340 FILE NO. 4 AND 6

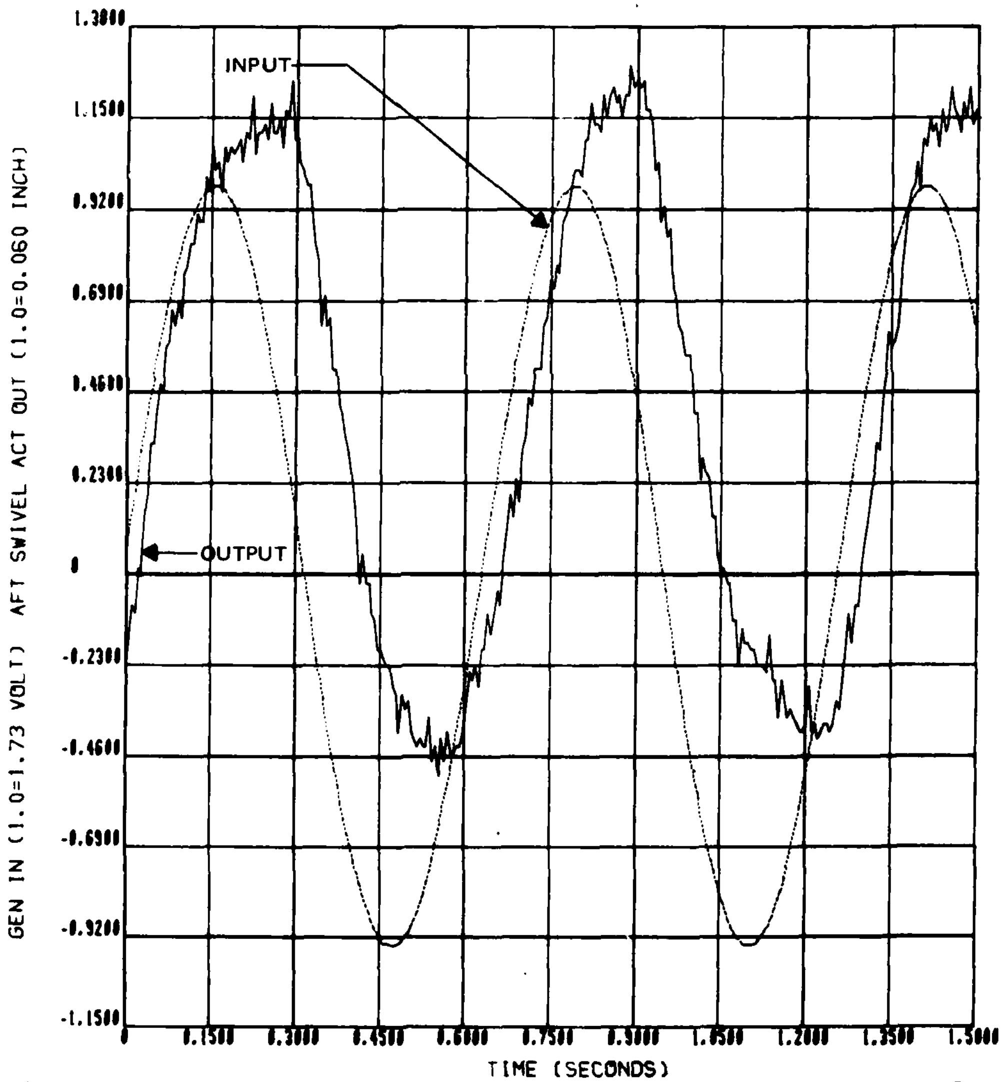
FIGURE 66

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

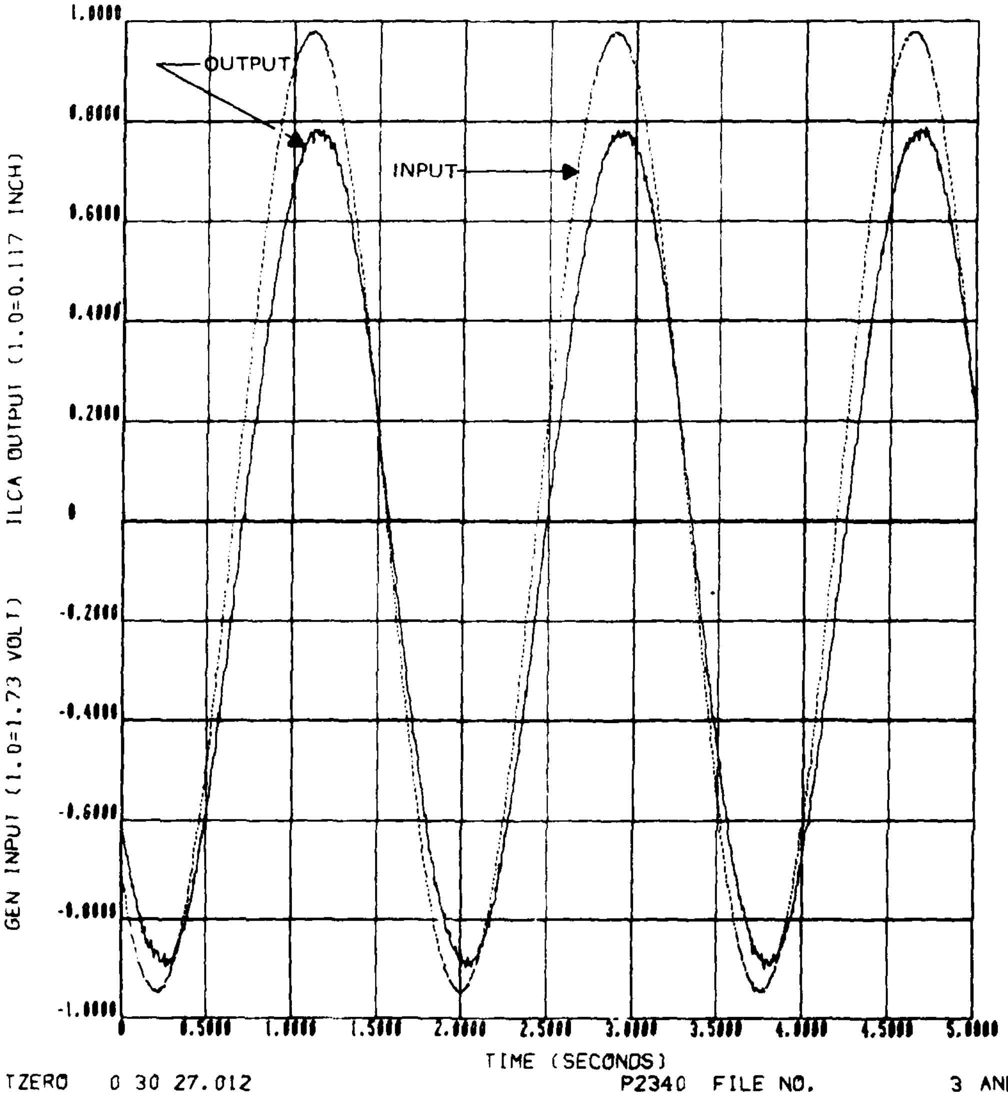
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈ 1.6 Hz
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
5. TIME SINCE ENGINE START -11 MINUTES



TZERO 0 31 45.038 P2340 FILE NO. 5 AND 2

FIGURE 67
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

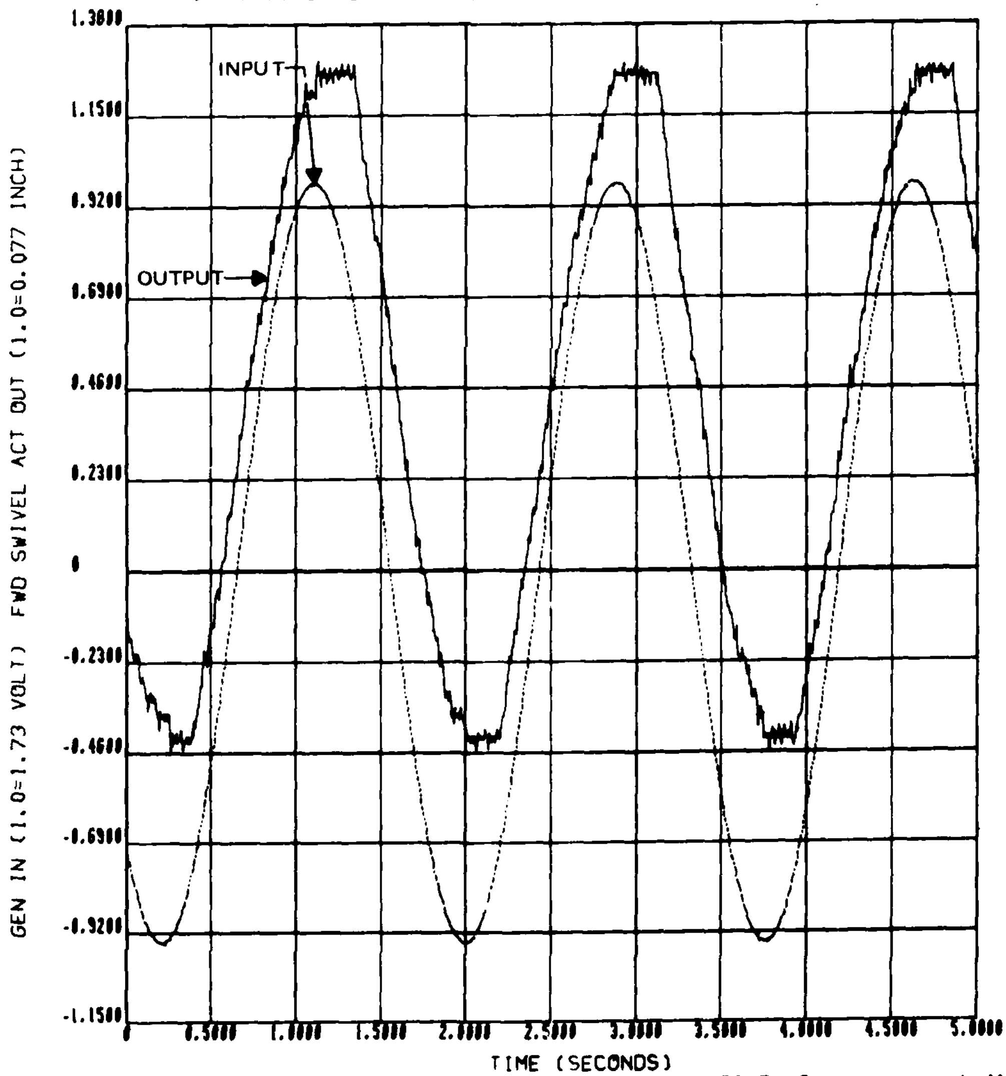
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈ 0.6 Hz
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C
   OUT -27° C
5. TIME SINCE ENGINE START - 11 MINUTES



TZERO 0 30 27.012 P2340 FILE NO. 3 AND 1

FIGURE 68
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

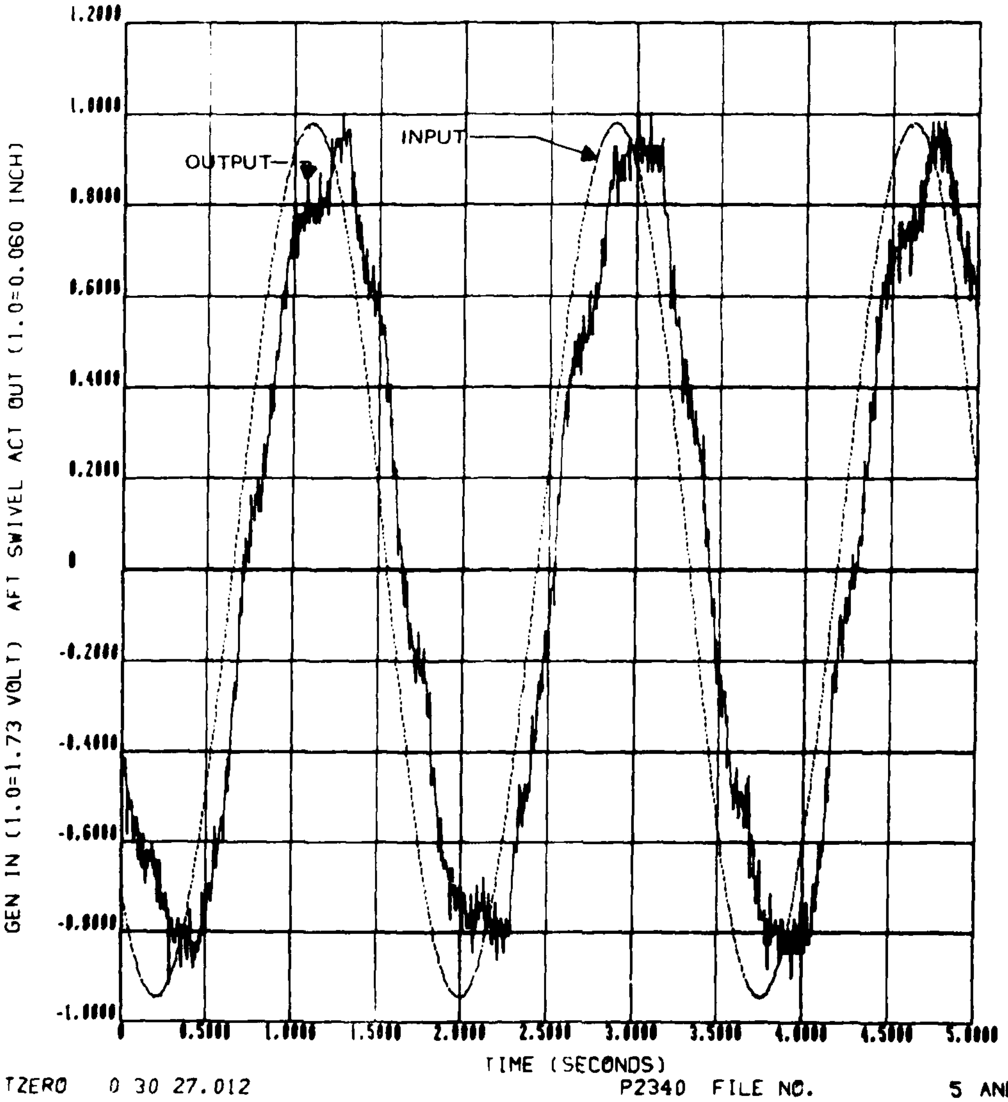
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈ 0.6 Hz
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
5. TIME SINCE ENGINE START - 11 MINUTES



TZERO 0 30 27.012 P2340 FILE NO. 4 AND 6

FIGURE 69
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

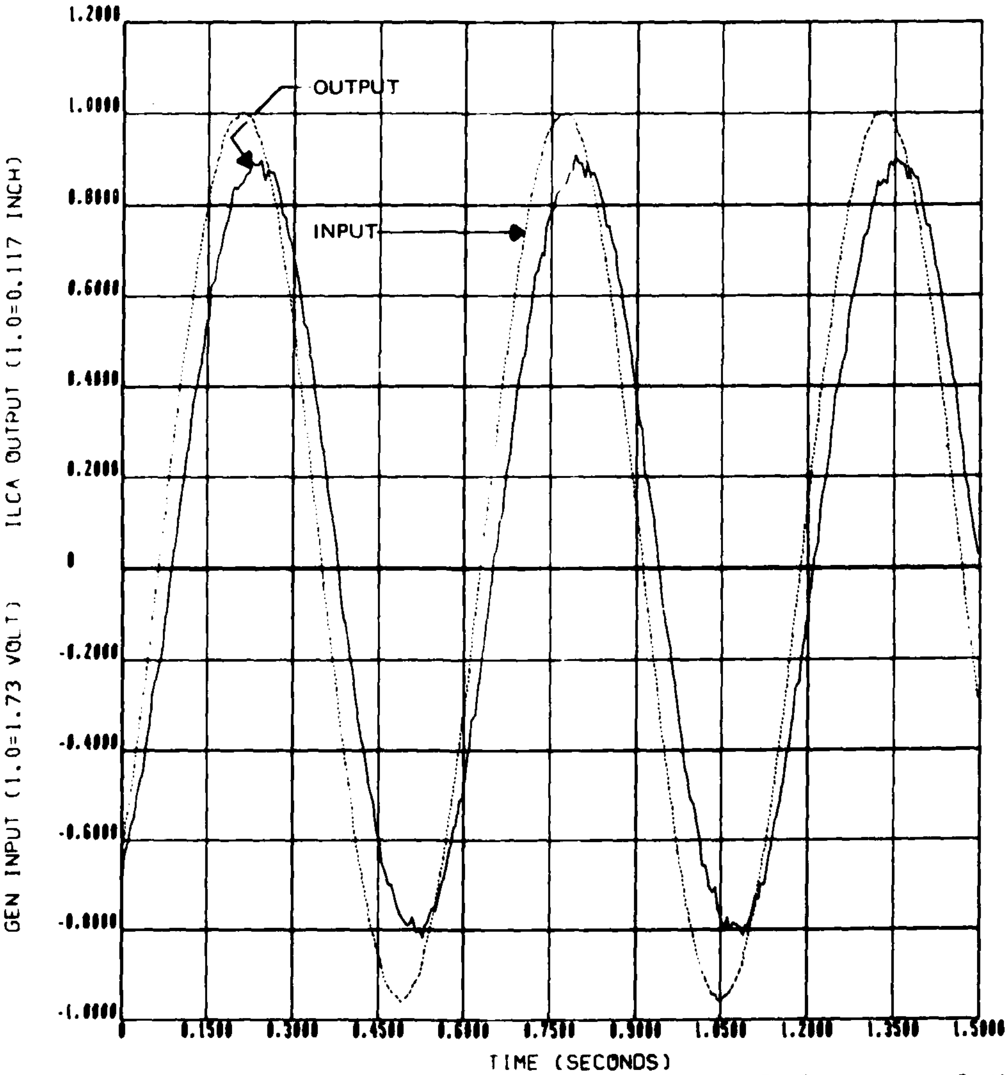
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈ 0.6 Hz
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -23° C OUT -27° C
5. TIME SINCE ENGINE START - 11 MINUTES



TZERO 0 30 27.012 P2340 FILE NO. 5 AND 2

FIGURE 70
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

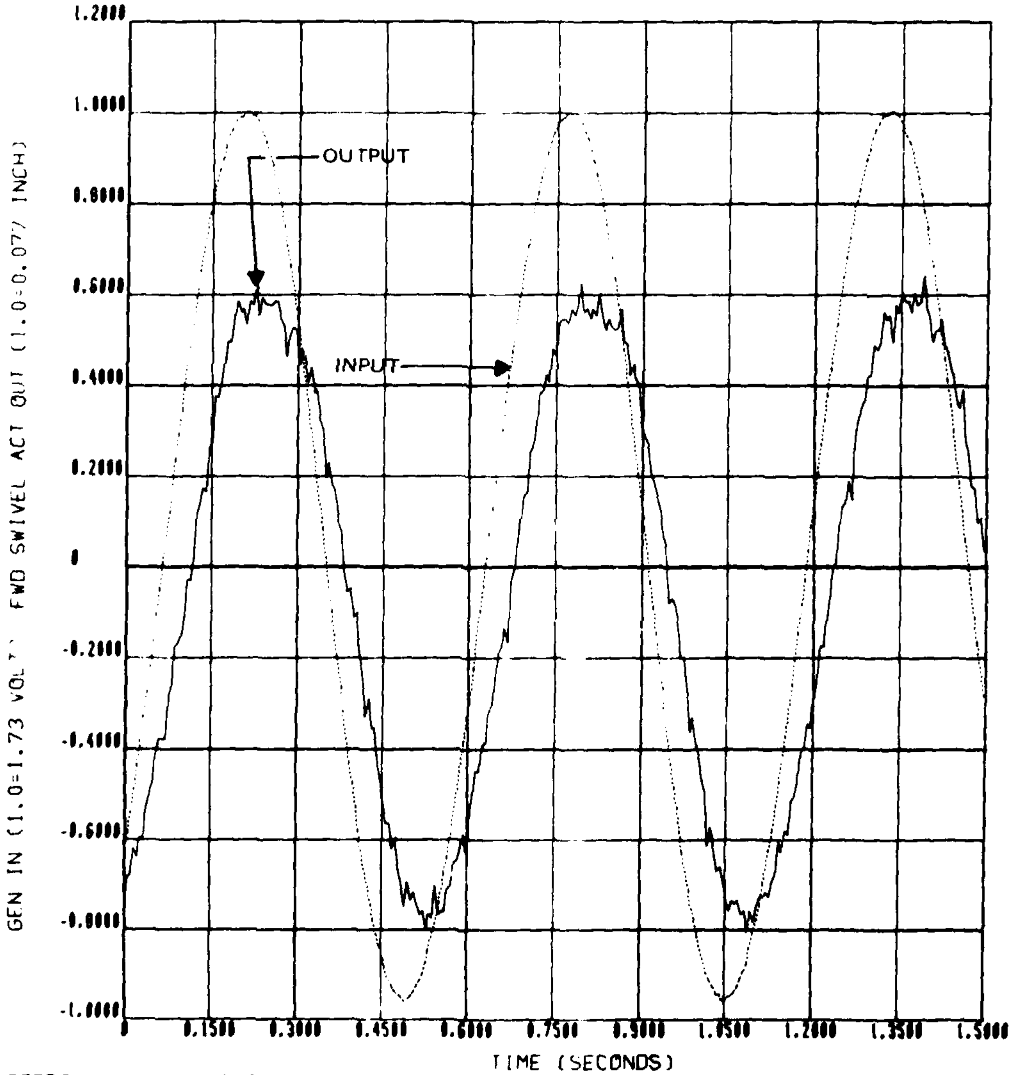
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈1.8 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES



TZERO 0 36 38.037 P2340 FILE NO. 3 AND 1

FIGURE 71
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

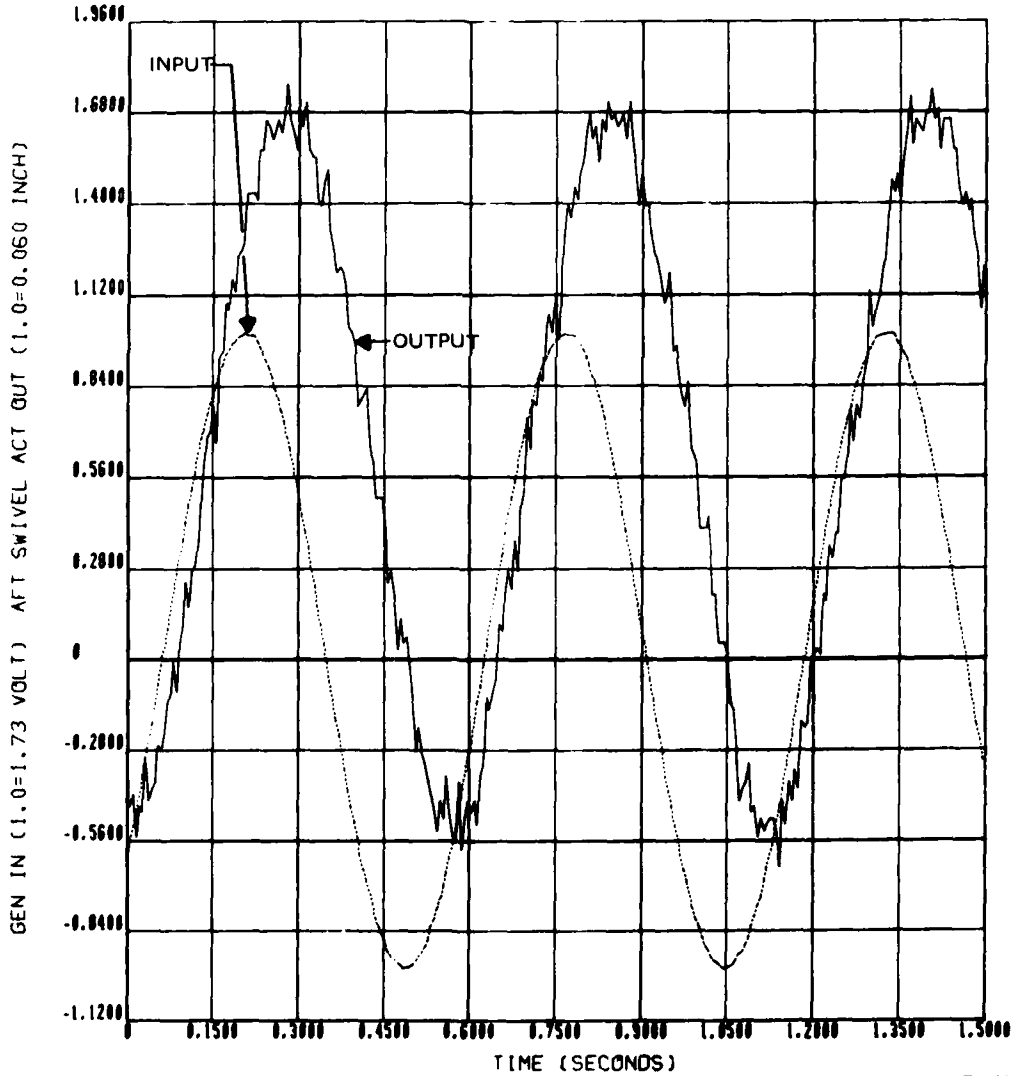
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈1.8 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES



TZERO 0 36 38.037 P2340 FILE NO. 4 AND 6

FIGURE 72
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈1.8 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES



TZERO 0 36 38.037 P2340 FILE NO. 5 AND 2

FIGURE 73
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.6 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C
OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES

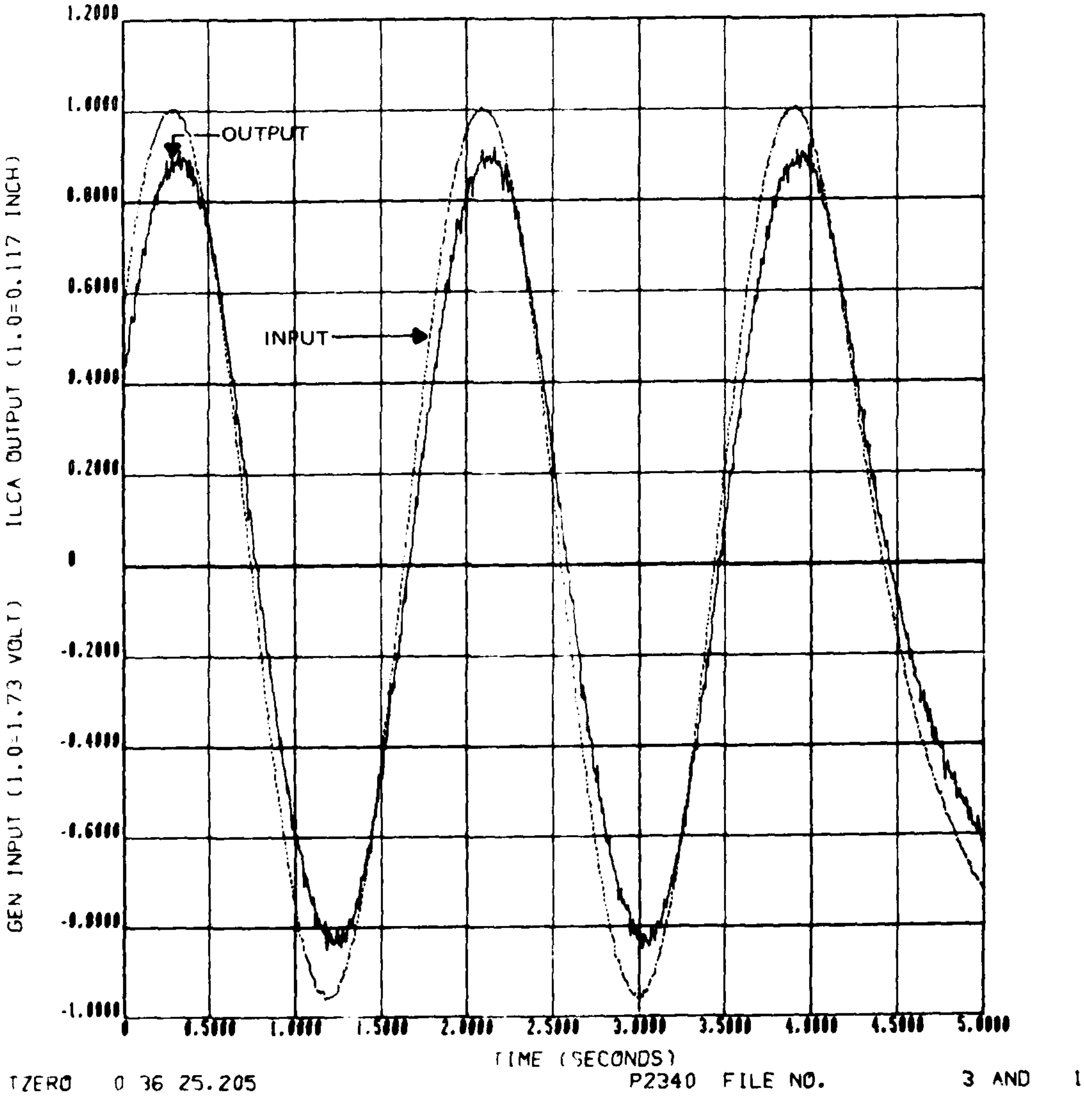
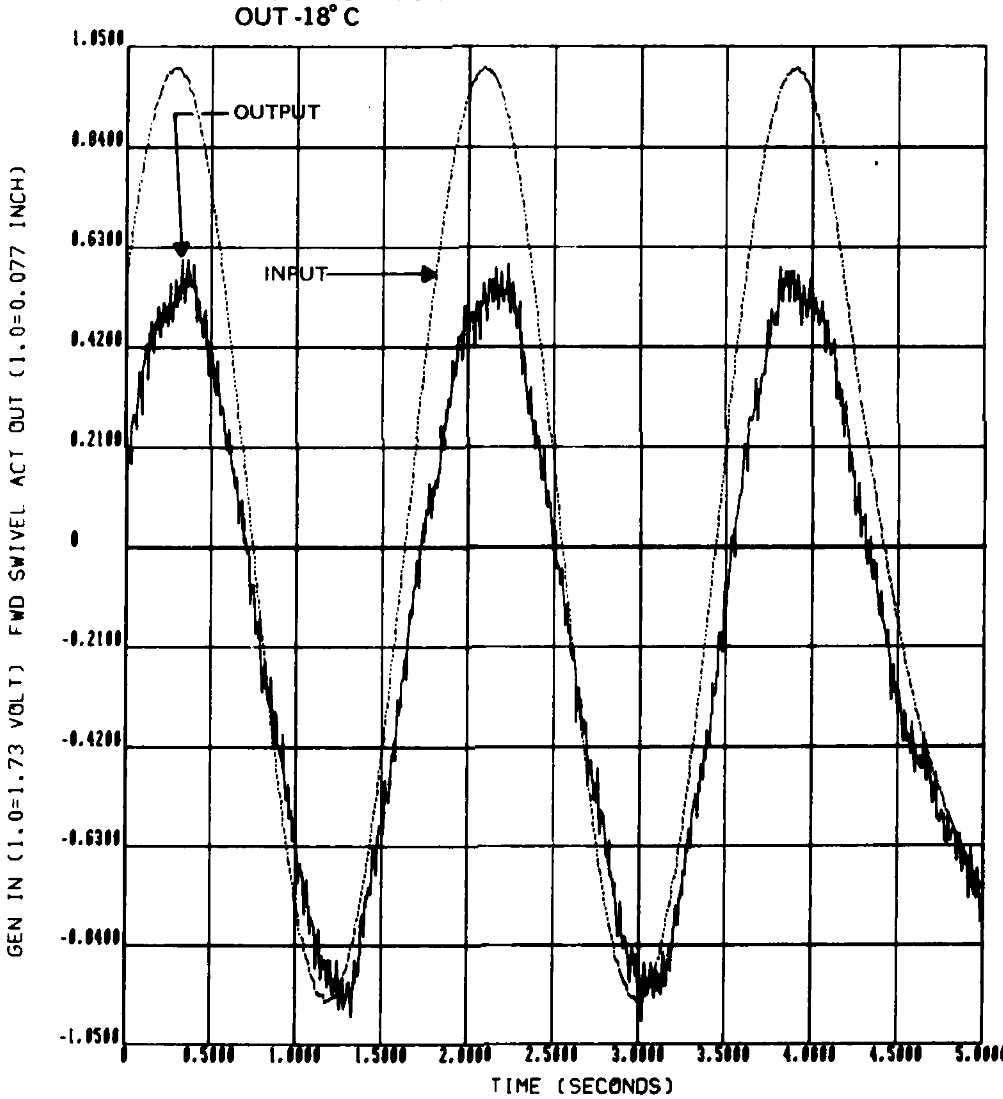


FIGURE 74
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.6 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C



TZERO 0 36 25.205 P2340 FILE NO. 4 AND 6

FIGURE 75
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.6 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES

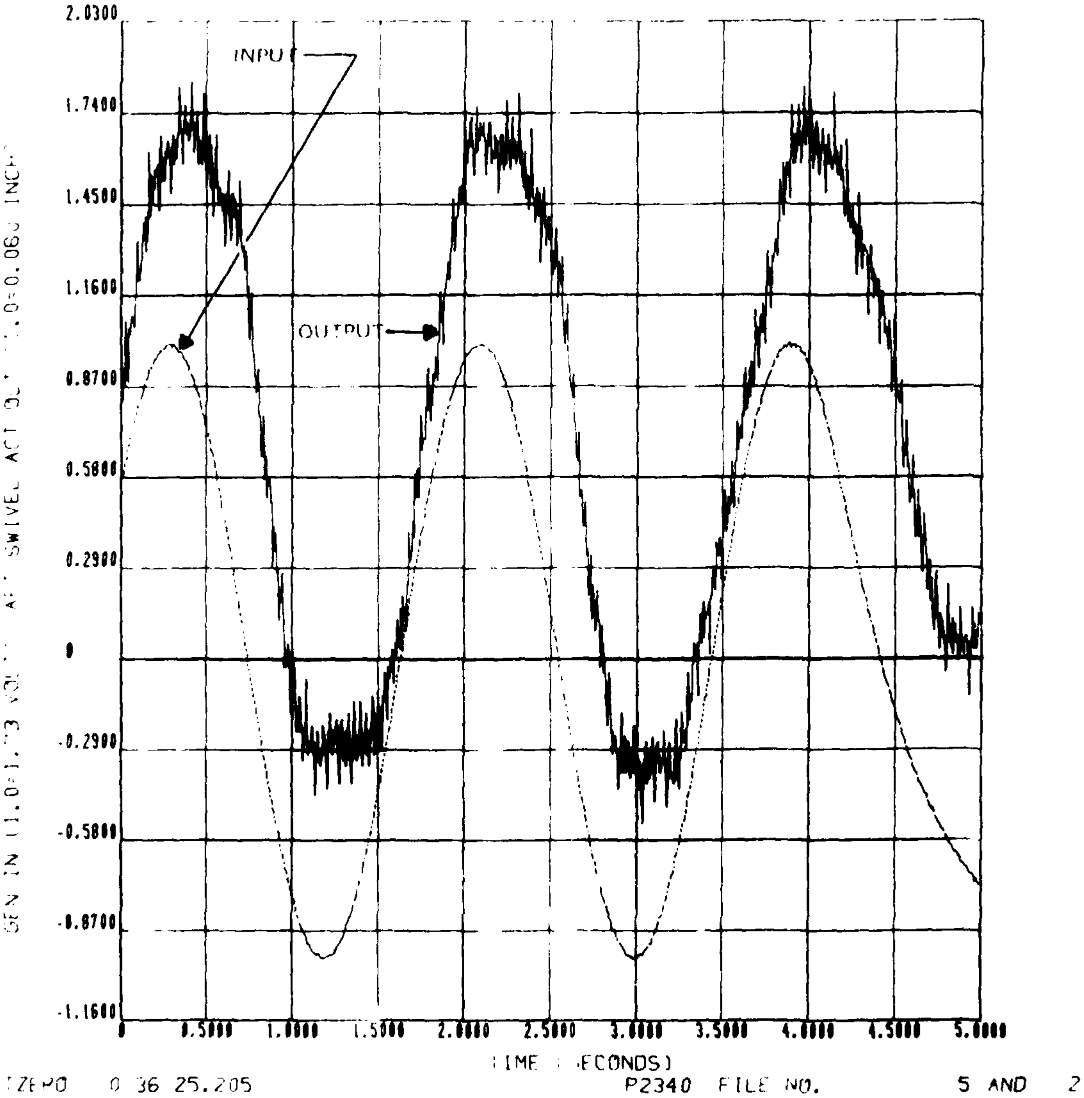


FIGURE 76

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT

2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

3. FREQUENCY ≈0.1 HZ

4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C

5. TIME SINCE ENGINE START - 18 MINUTES

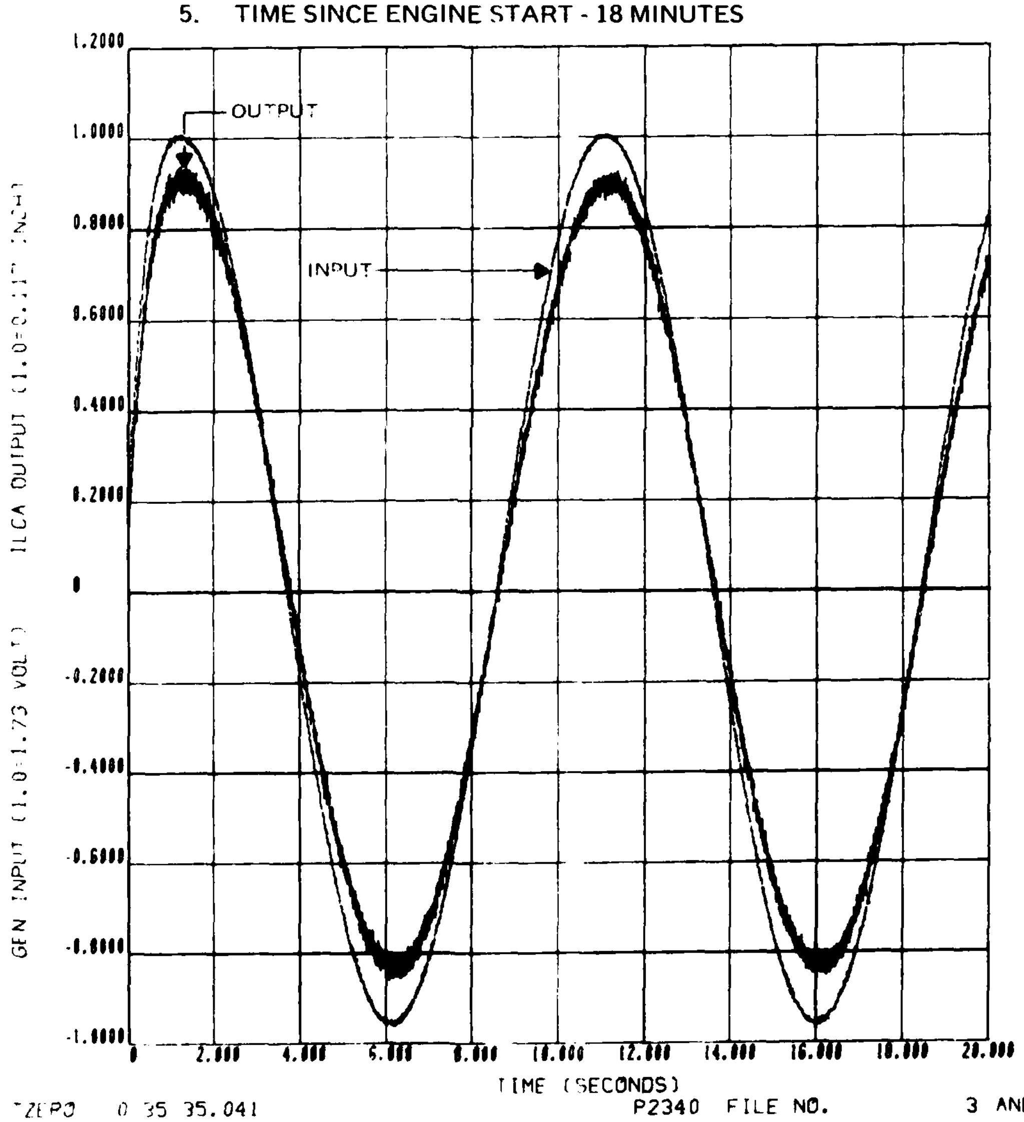


FIGURE 77
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.1 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES

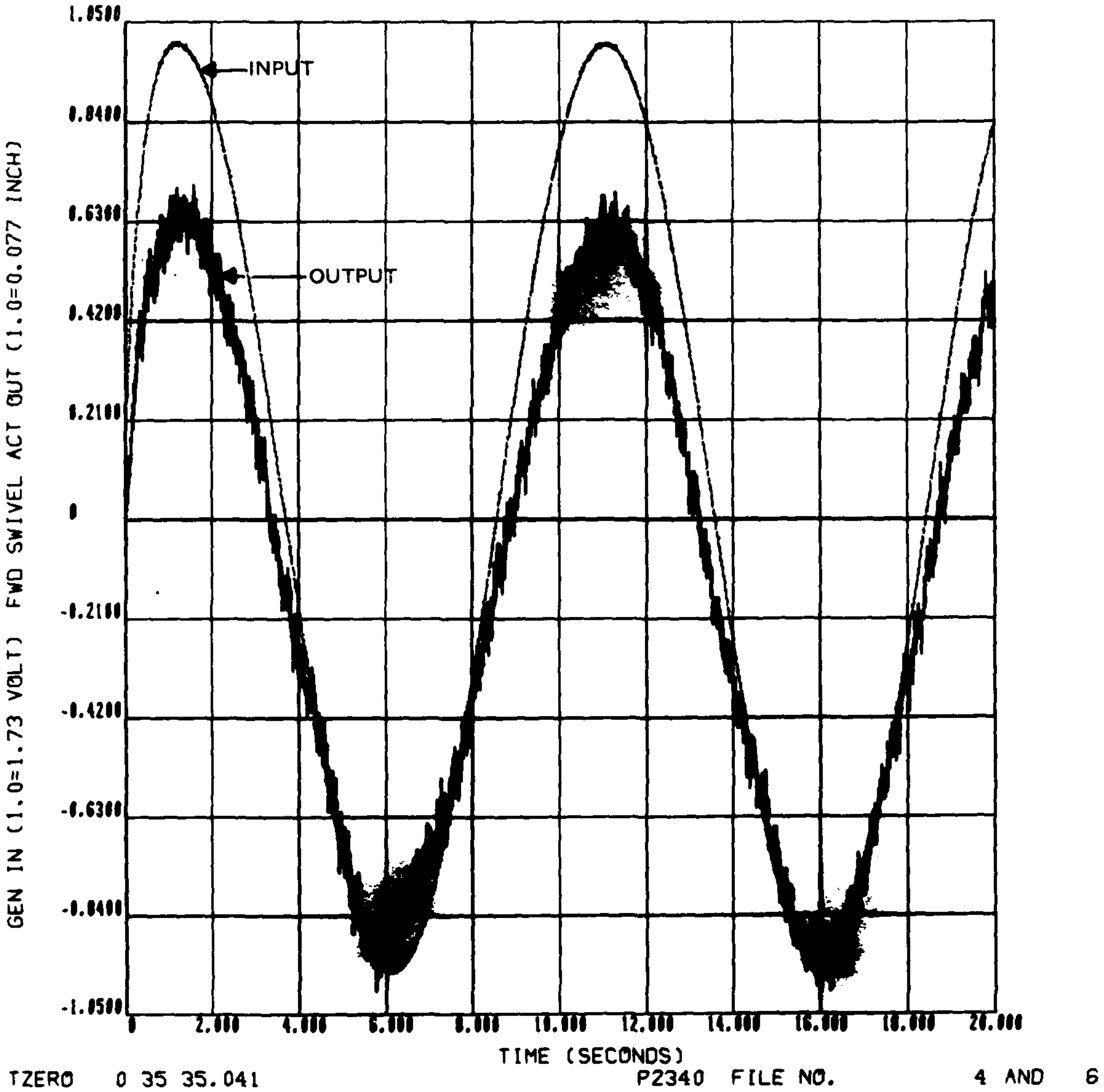
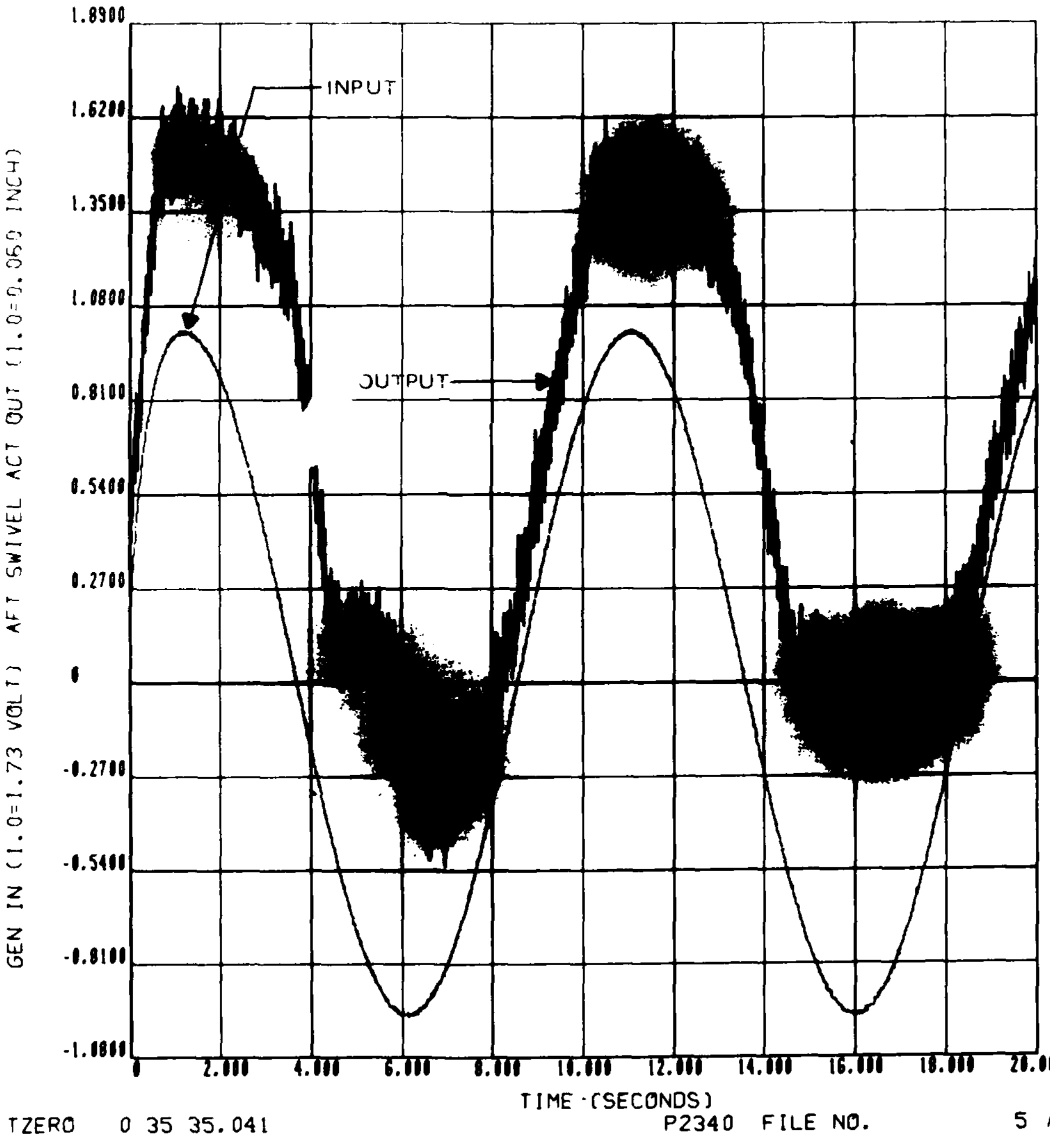


FIGURE 78
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

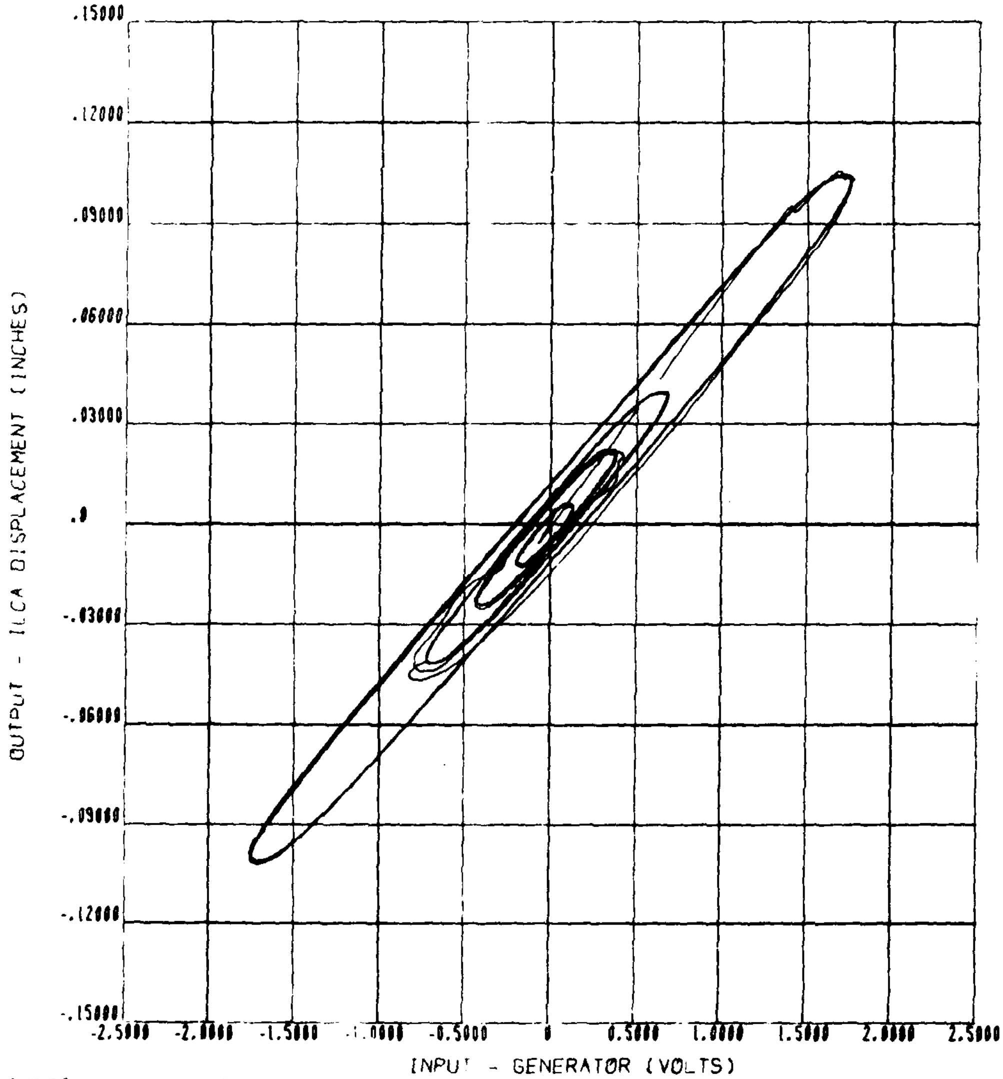
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.1 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN -14° C OUT -18° C
5. TIME SINCE ENGINE START - 18 MINUTES



TZERO 0 35 35.041 P2340 FILE NO. 5 AND 2

FIGURE 79
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F
ILCA DISPLACEMENT

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. NO. 1 RESERVOIR COOLER TEMPERATURE IN -16° C OUT -21° C
3. TARGET FREQUENCY 0.32 Hz
4. TARGET AMPLITUDES ±0.020, ±0.040, ±0.060, and ±0.125 IN.



7 TZERO 0 24 13.014 P2340 FILE NO. 1 AND 3

FIGURE 80

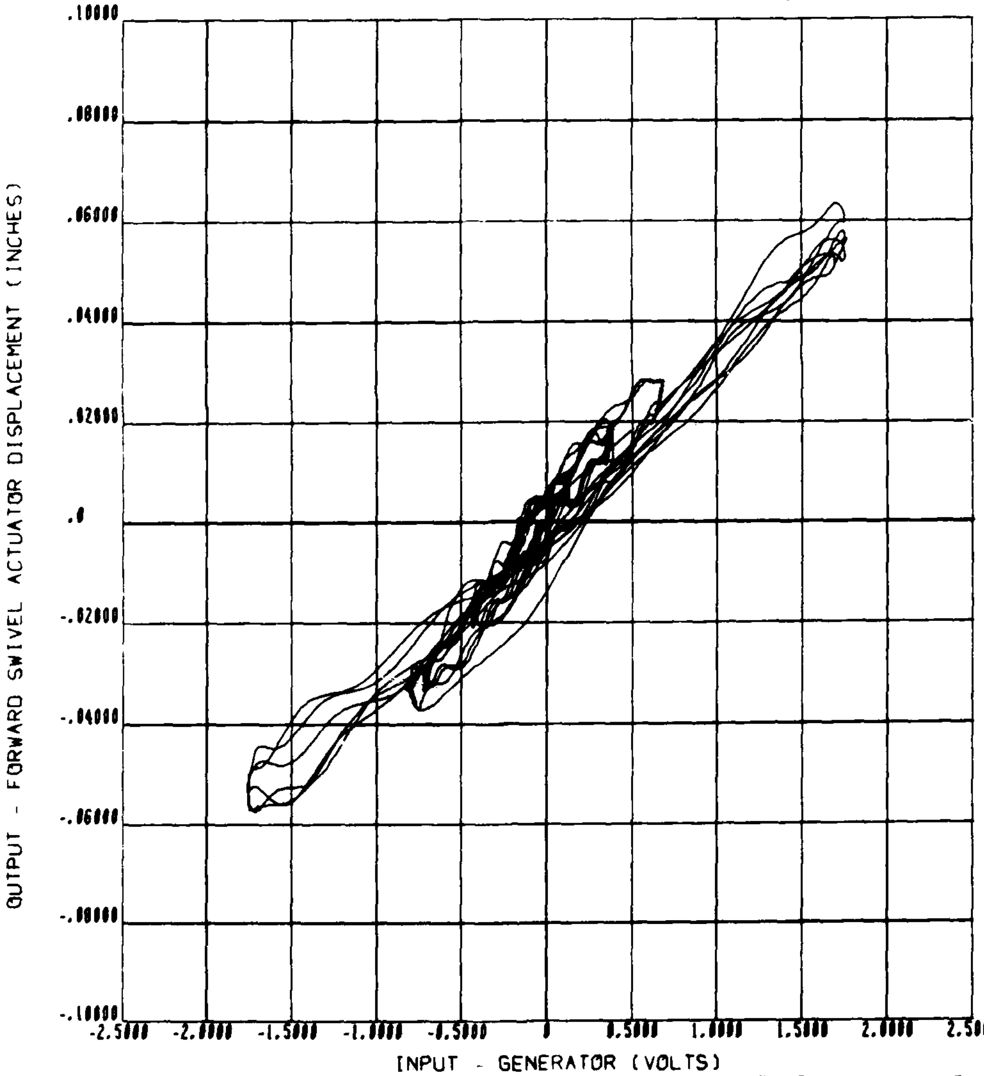
FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -50° F

FWD SWIVELING ACTUATOR DISPLACEMENT

NOTES:
1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. NO. 1 RESERVOIR COOLER TEMPERATURE IN -16° C OUT -21° C
3. TARGET FREQUENCY 0.32 Hz
4. TARGET AMPLITUDES ±0.020, ±0.040, ±0.060, and ±0.125 IN.



TZERO 0 24 13.014 P2340 FILE NO. 6 AND 4

FIGURE 81

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -50° F

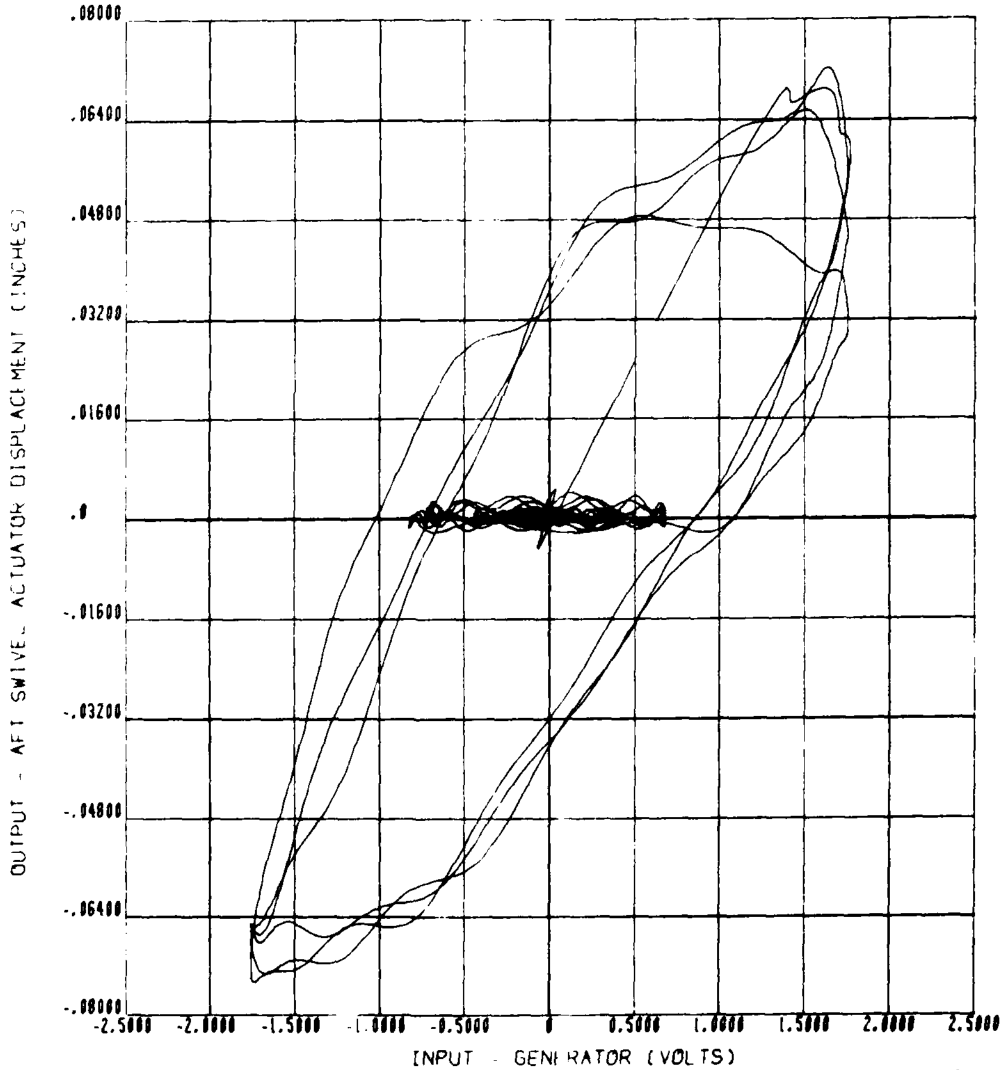
AFT SWIVELING ACTUATOR DISPLACEMENT

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

2. NO. 1 RESERVOIR COOLER TEMPERATURE IN -16° C OUT -21° C

3. TARGET FREQUENCY 0.32 Hz

4. TARGET AMPLITUDES ±0.020, ±0.040, ±0.060, and ±0.125 IN.



ZERO 0 24 13.014 P2340 FILE NO. 2 AND 5

FIGURE 82
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. PHASE PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

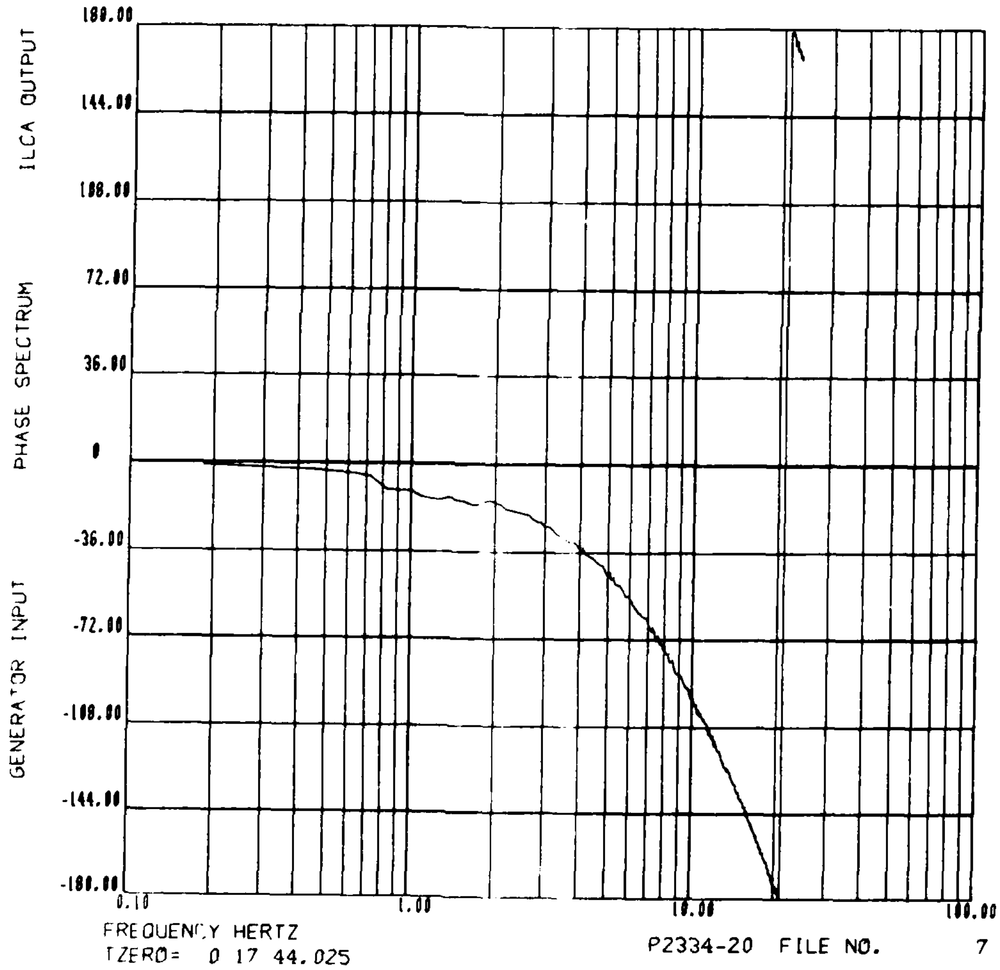


FIGURE 83
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. BODE PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

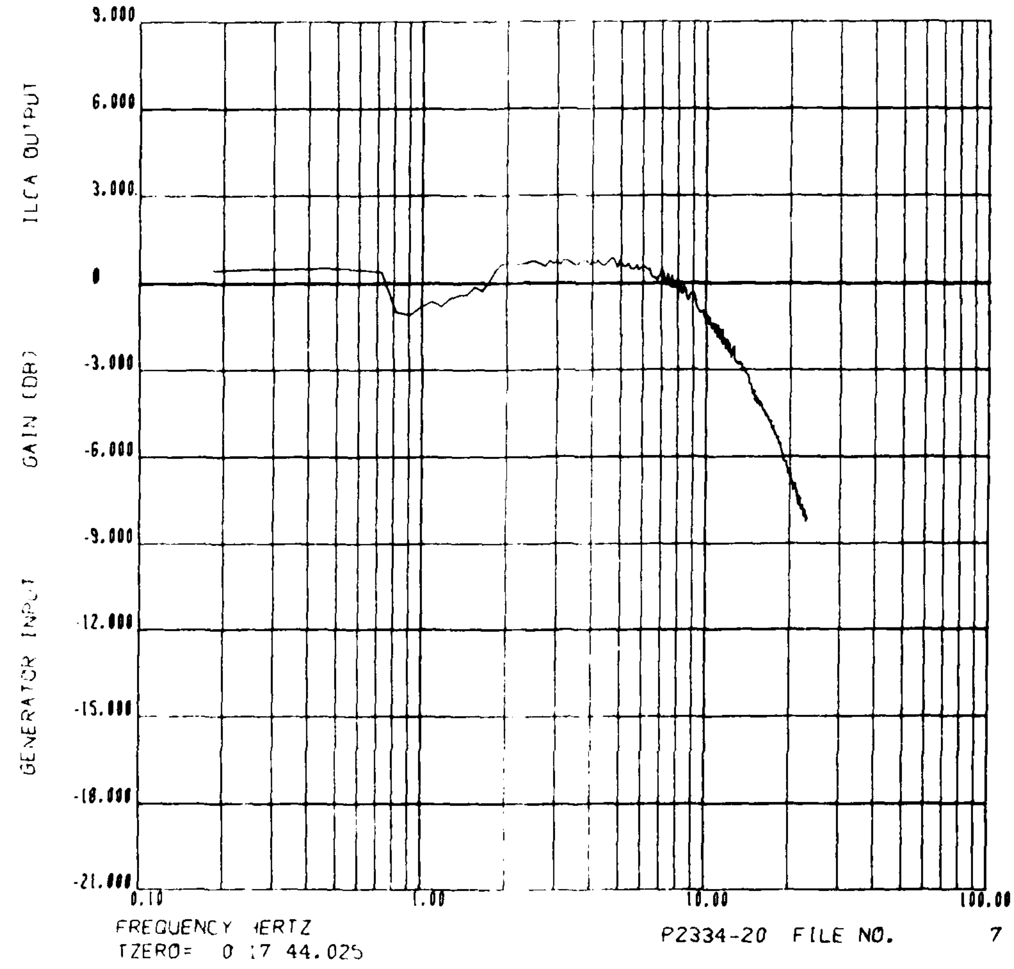


FIGURE 84
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. PHASE PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

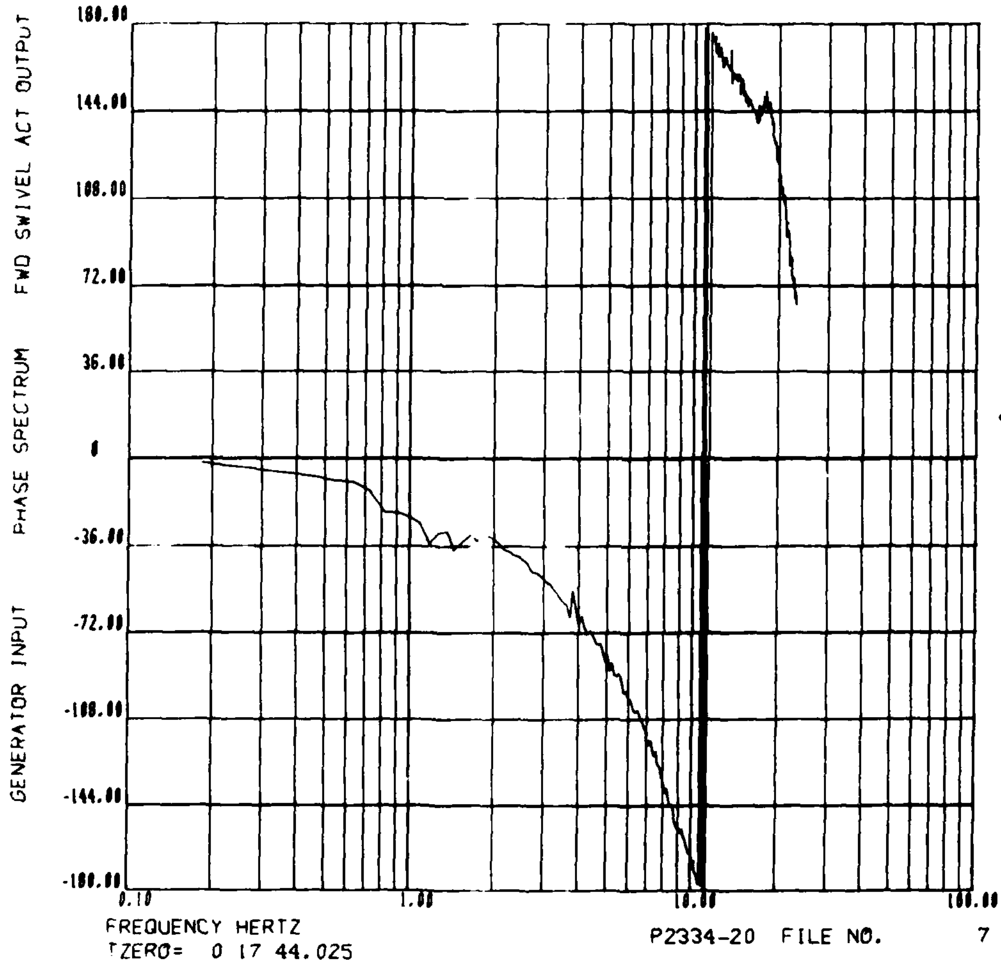


FIGURE 85
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. BODE PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

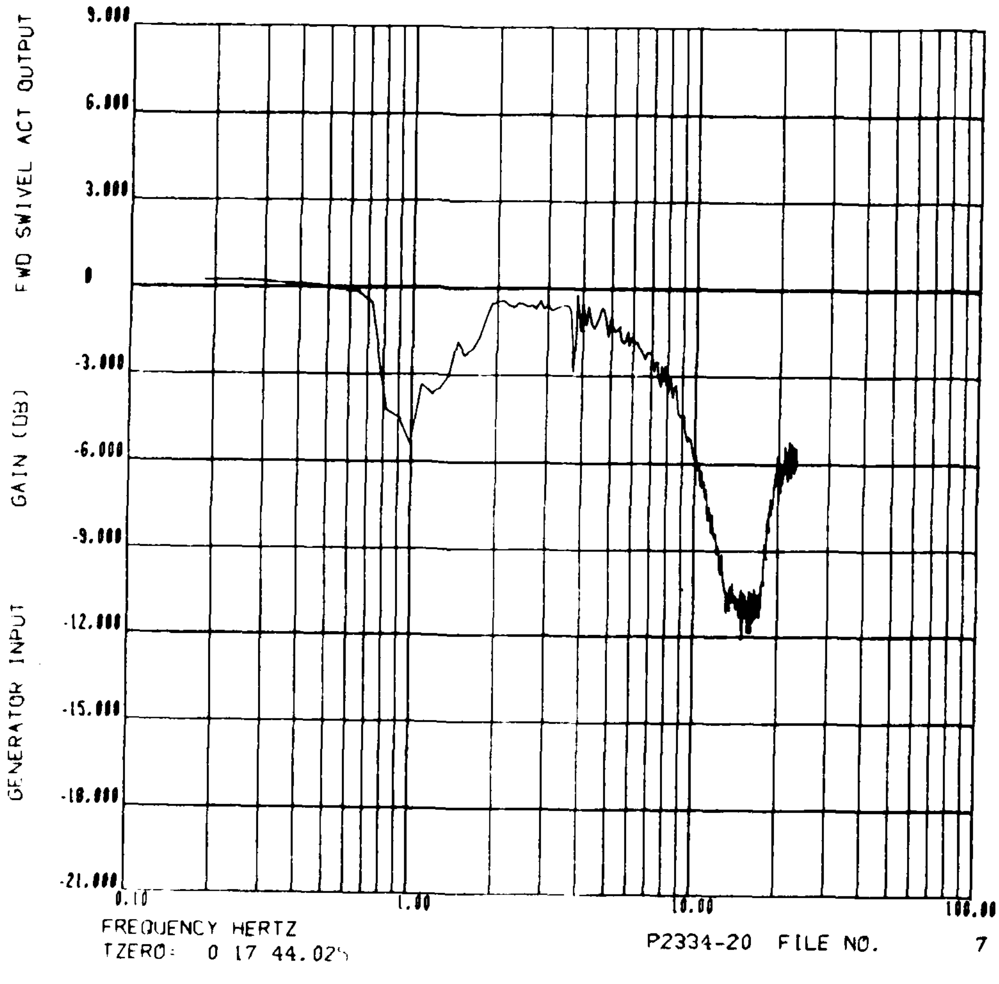


FIGURE 86

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. PHASE PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

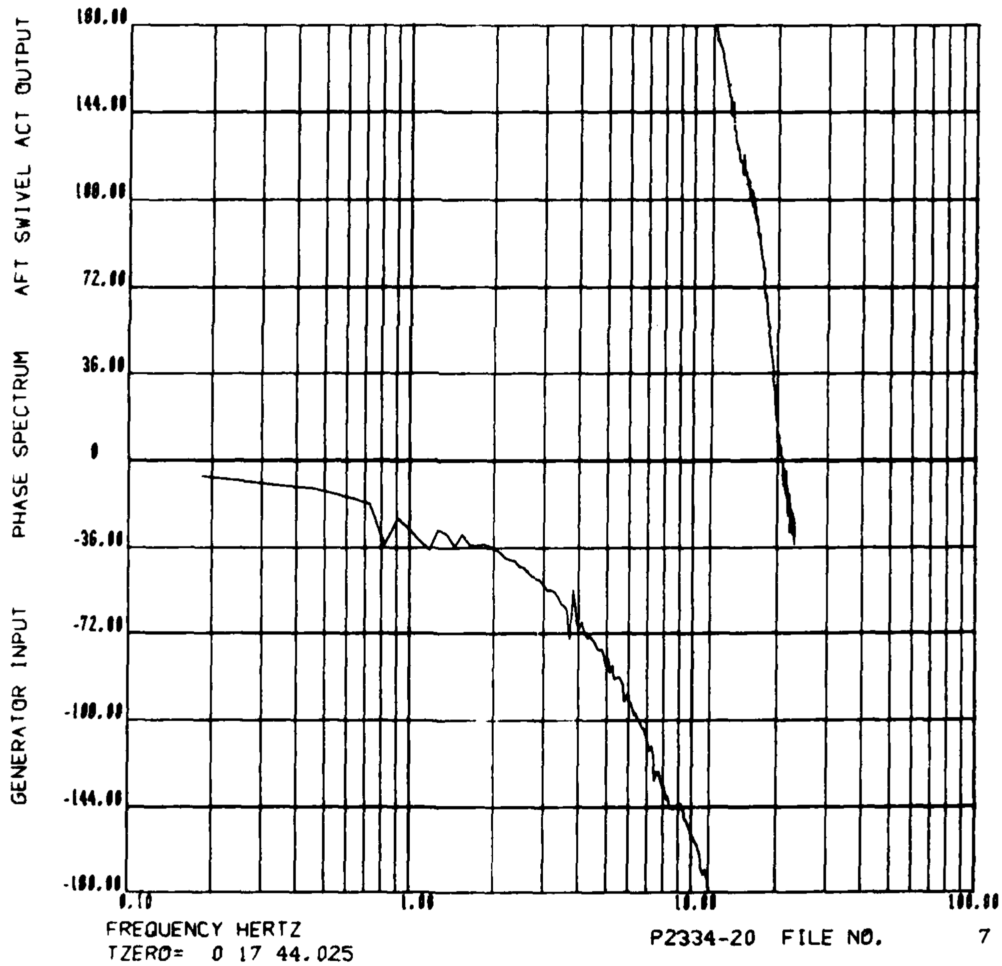


FIGURE 87

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. BODE PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT

2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C

4. TIME SINCE ENGINE START - 10 MINUTES

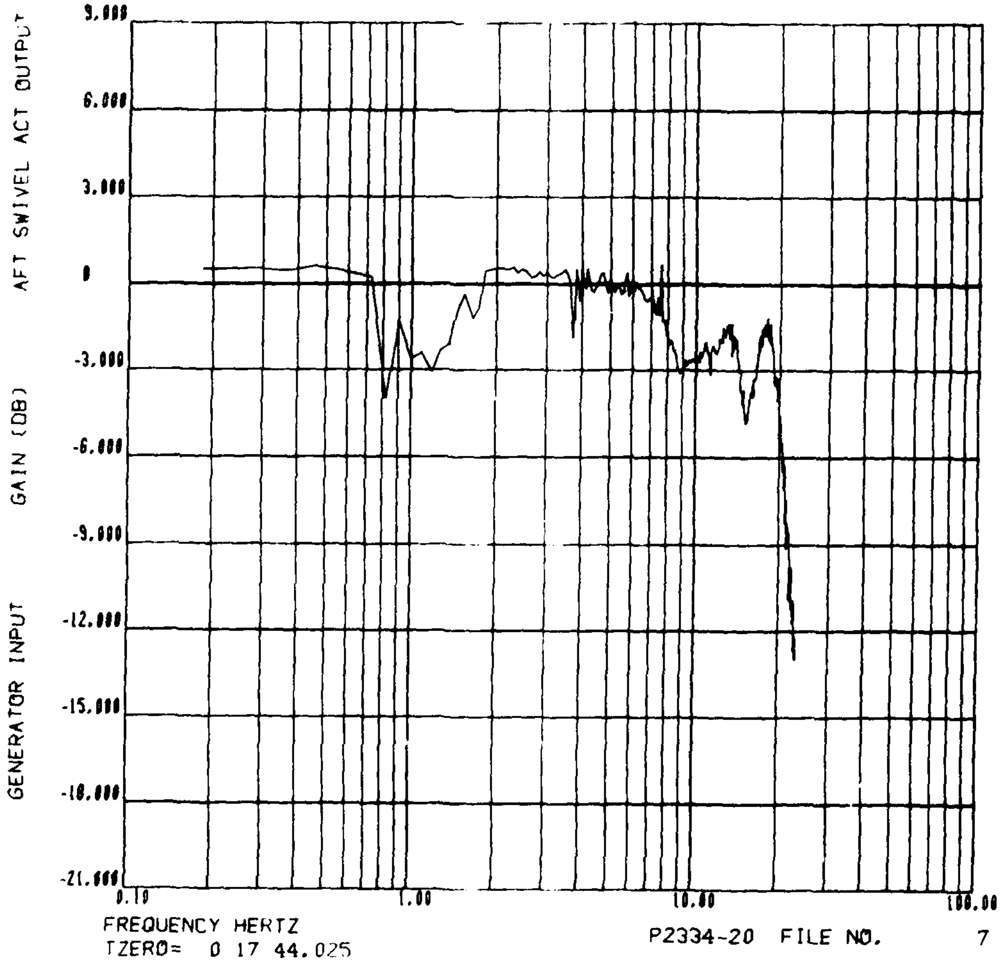


FIGURE 88
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. PHASE PLOT - ILCA INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

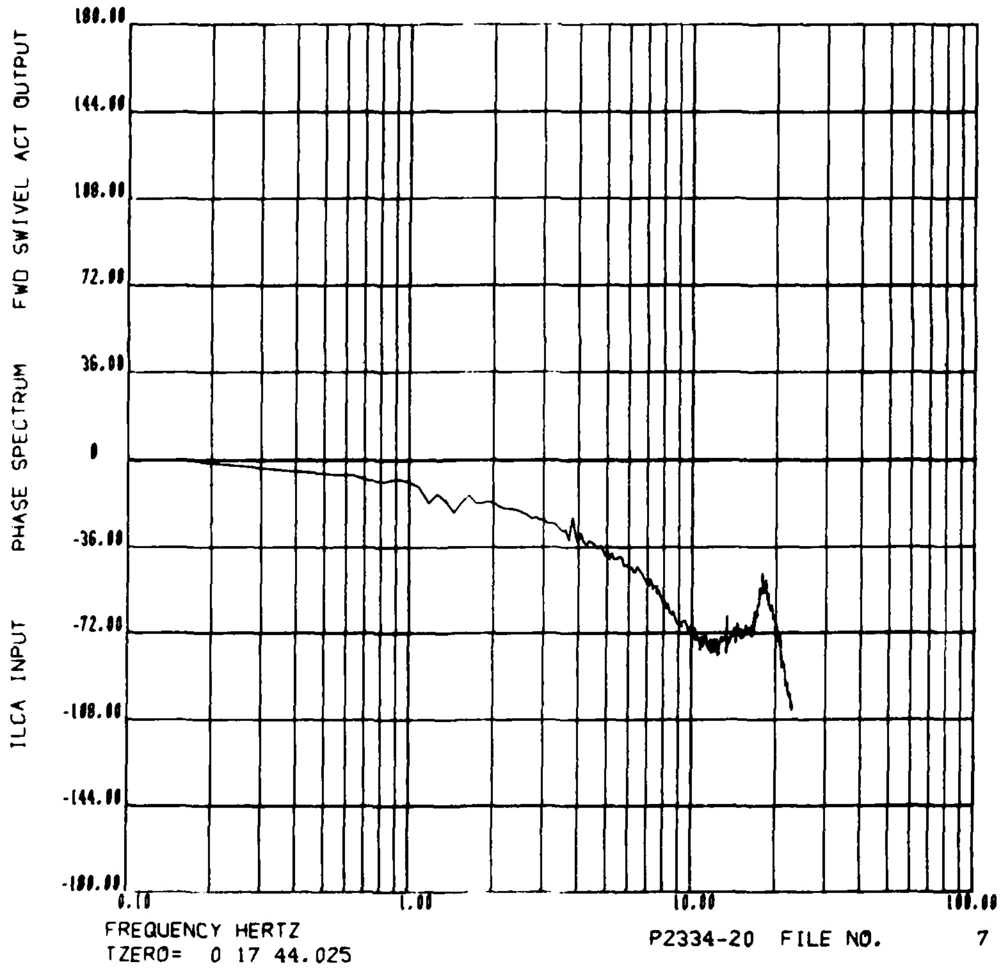


FIGURE 89
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. BODE PLOT - ILCA INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

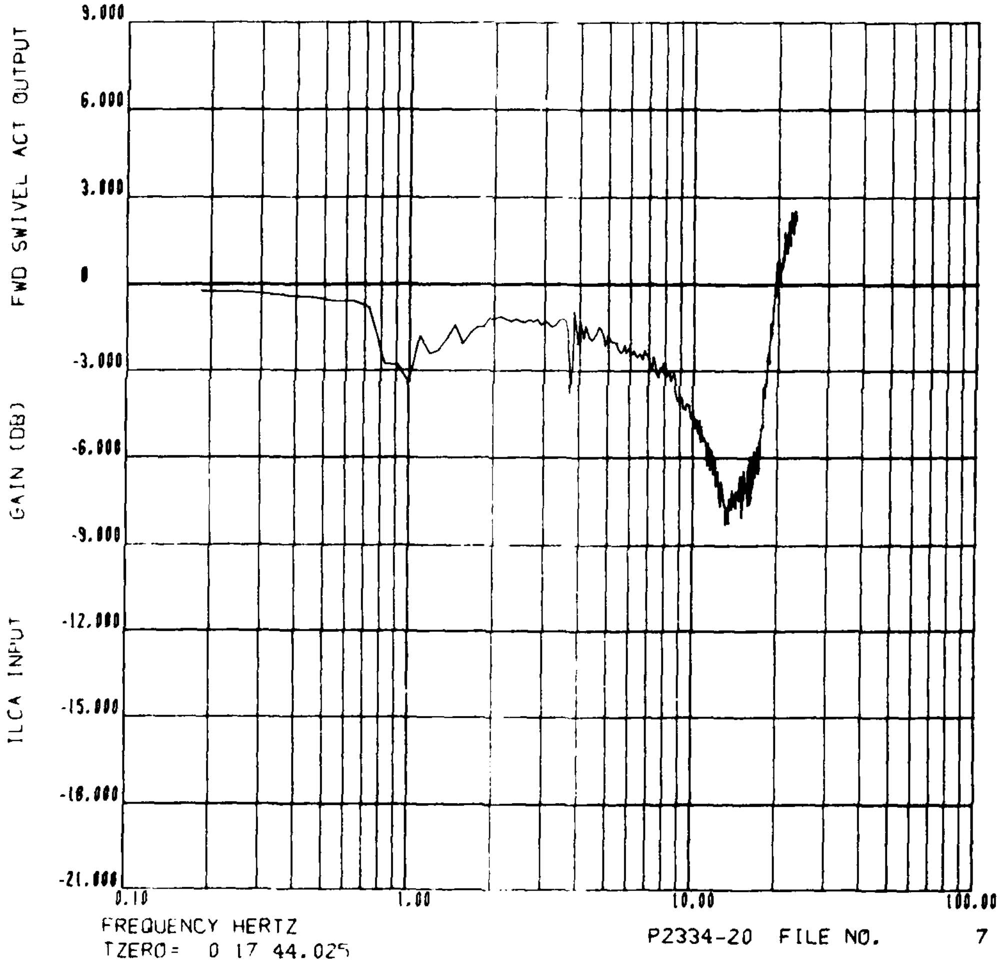


FIGURE 90
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. PHASE PLOT - ILCA INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C.
4. TIME SINCE ENGINE START - 10 MINUTES

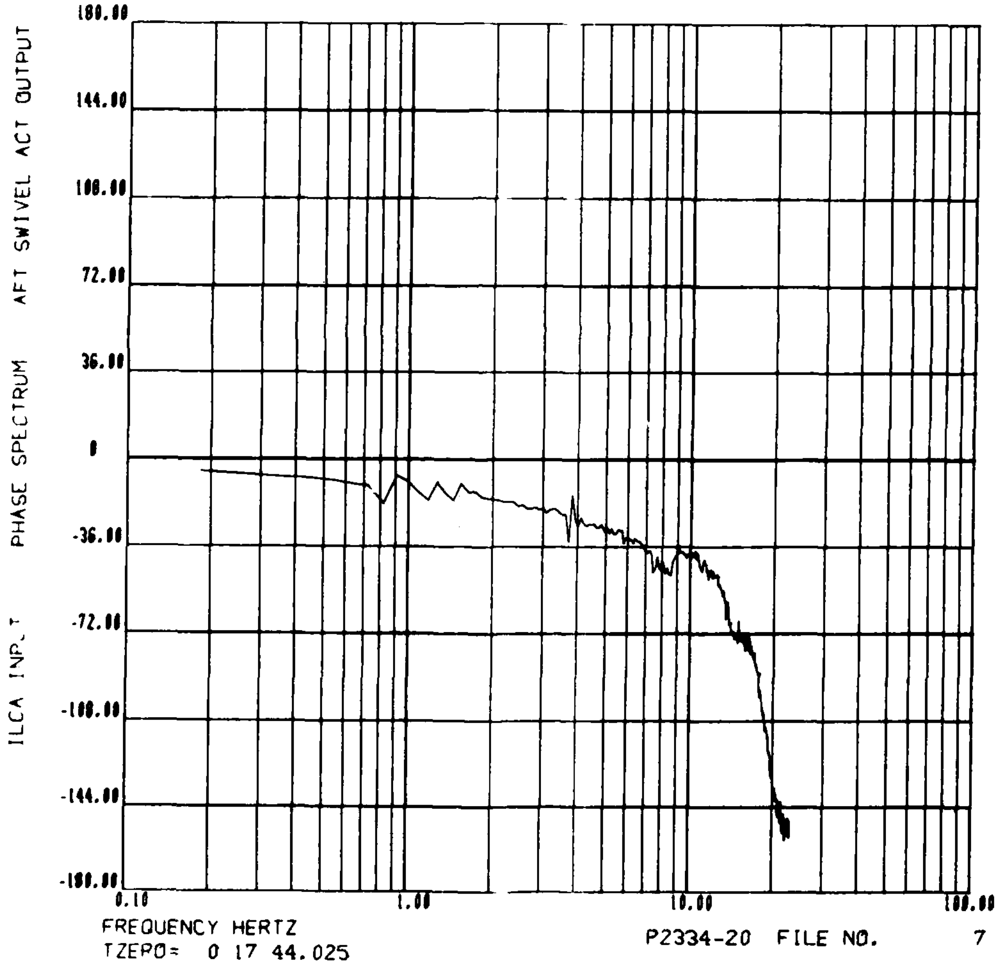


FIGURE 91
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. BODE PLOT - ILCA INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
4. TIME SINCE ENGINE START - 10 MINUTES

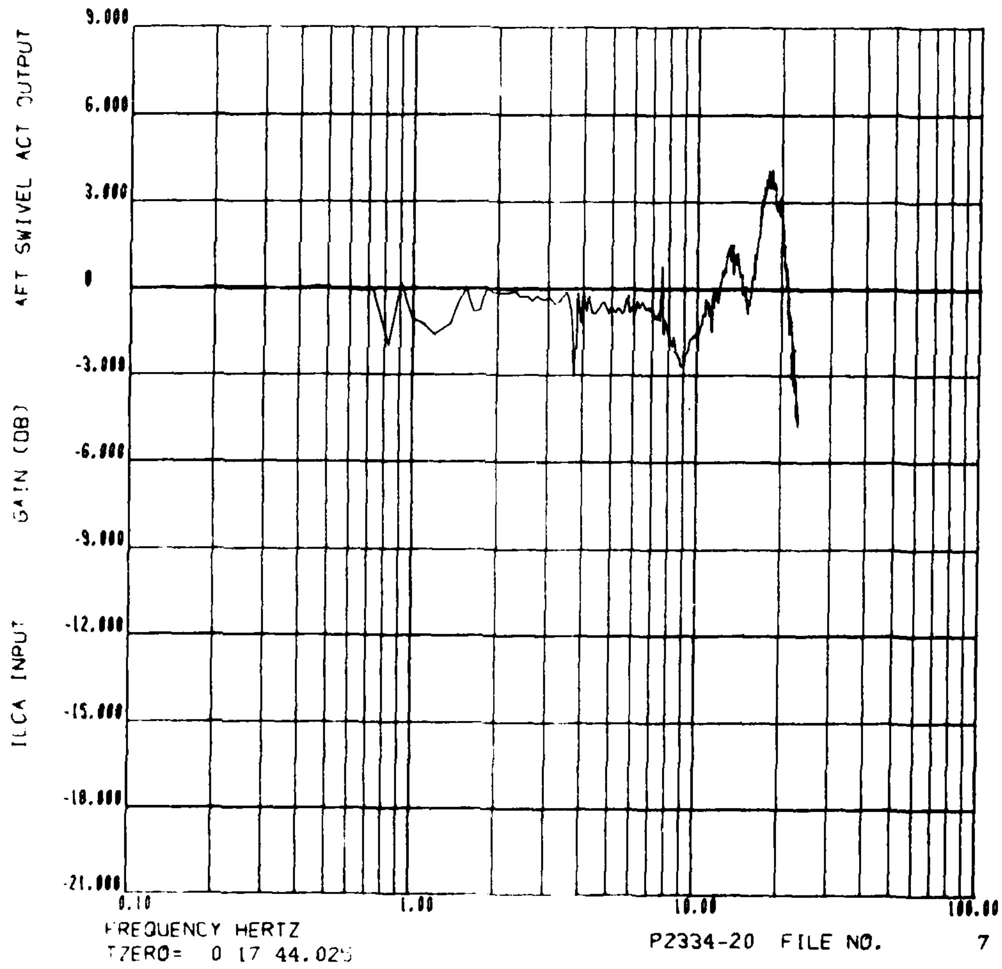
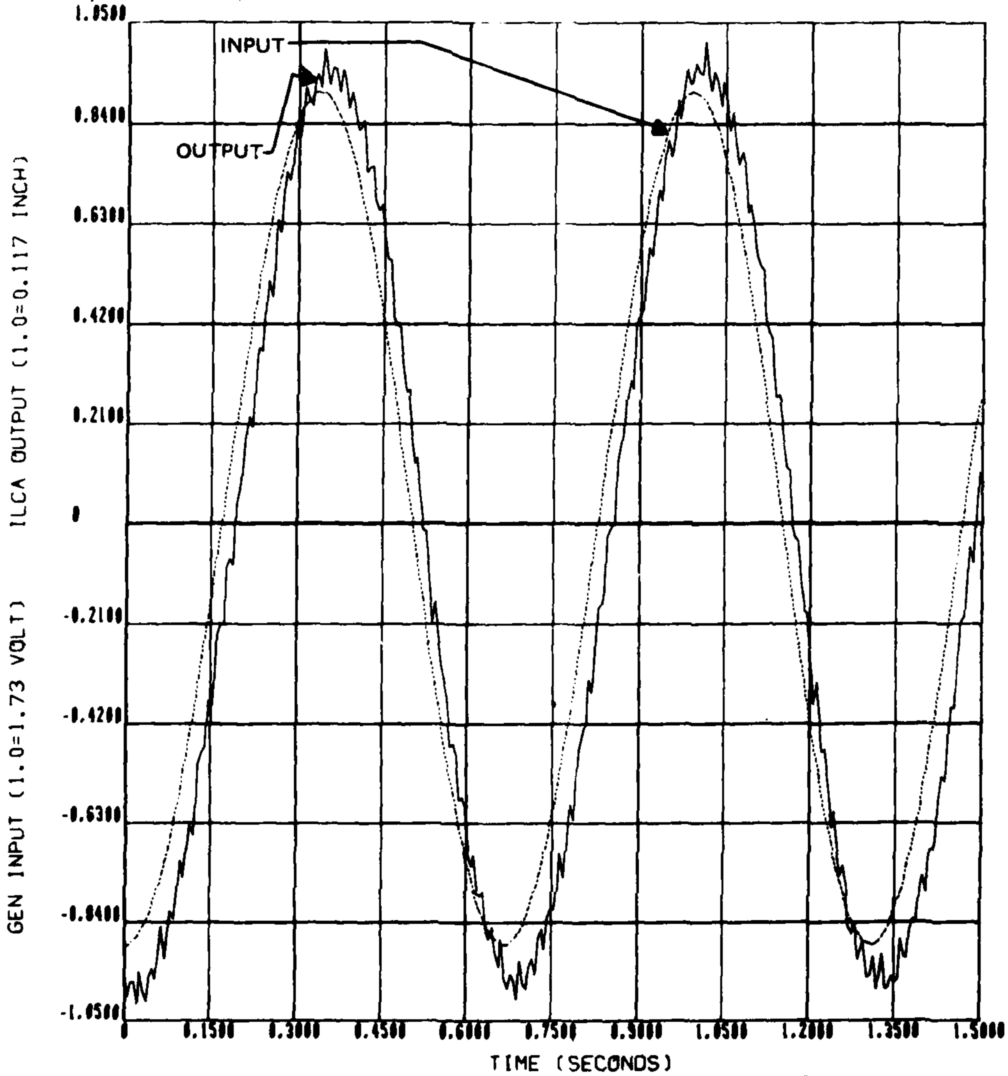


FIGURE 92
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈1.5 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
5. TIME SINCE ENGINE START -10 MINUTES



TZERO 0 20 36.008 P2340 FILE NO. 3 AND 1

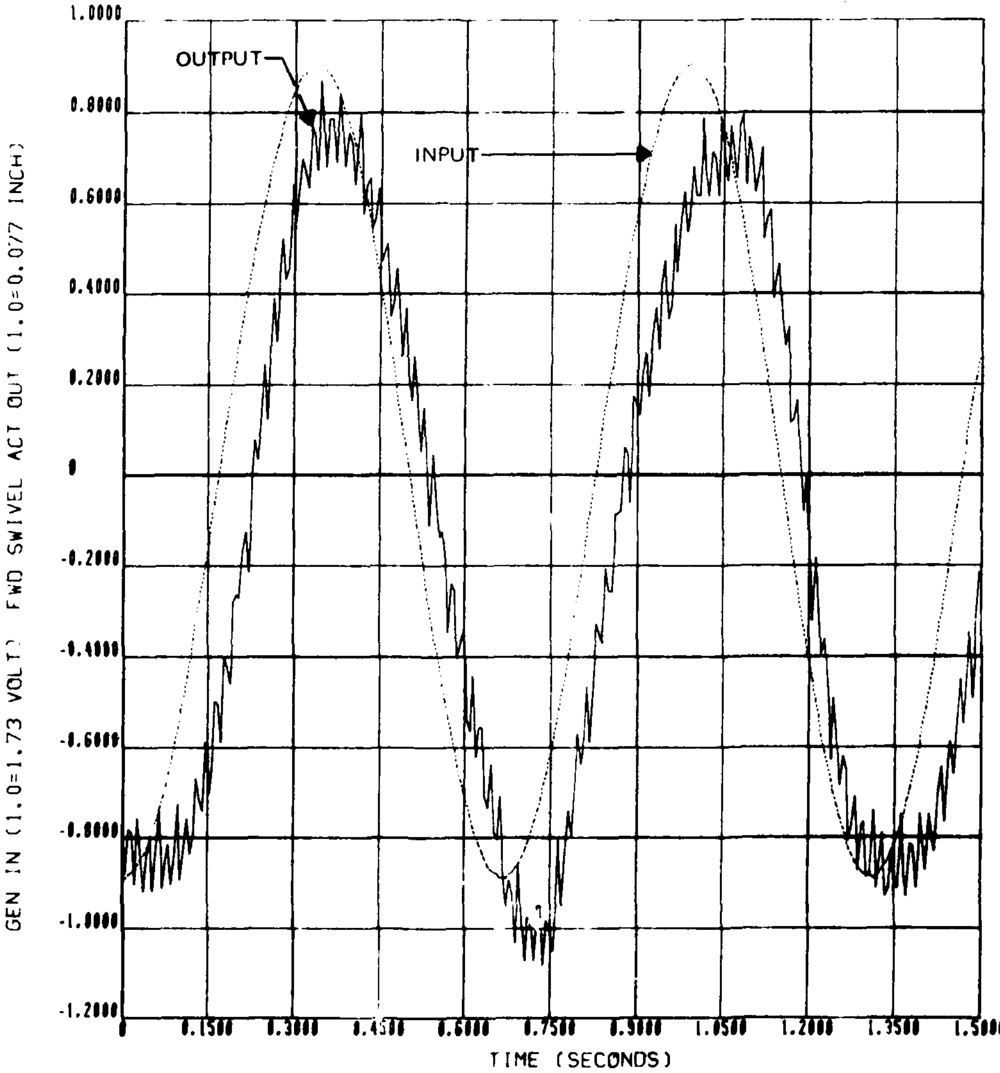
FIGURE 93

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 125° F

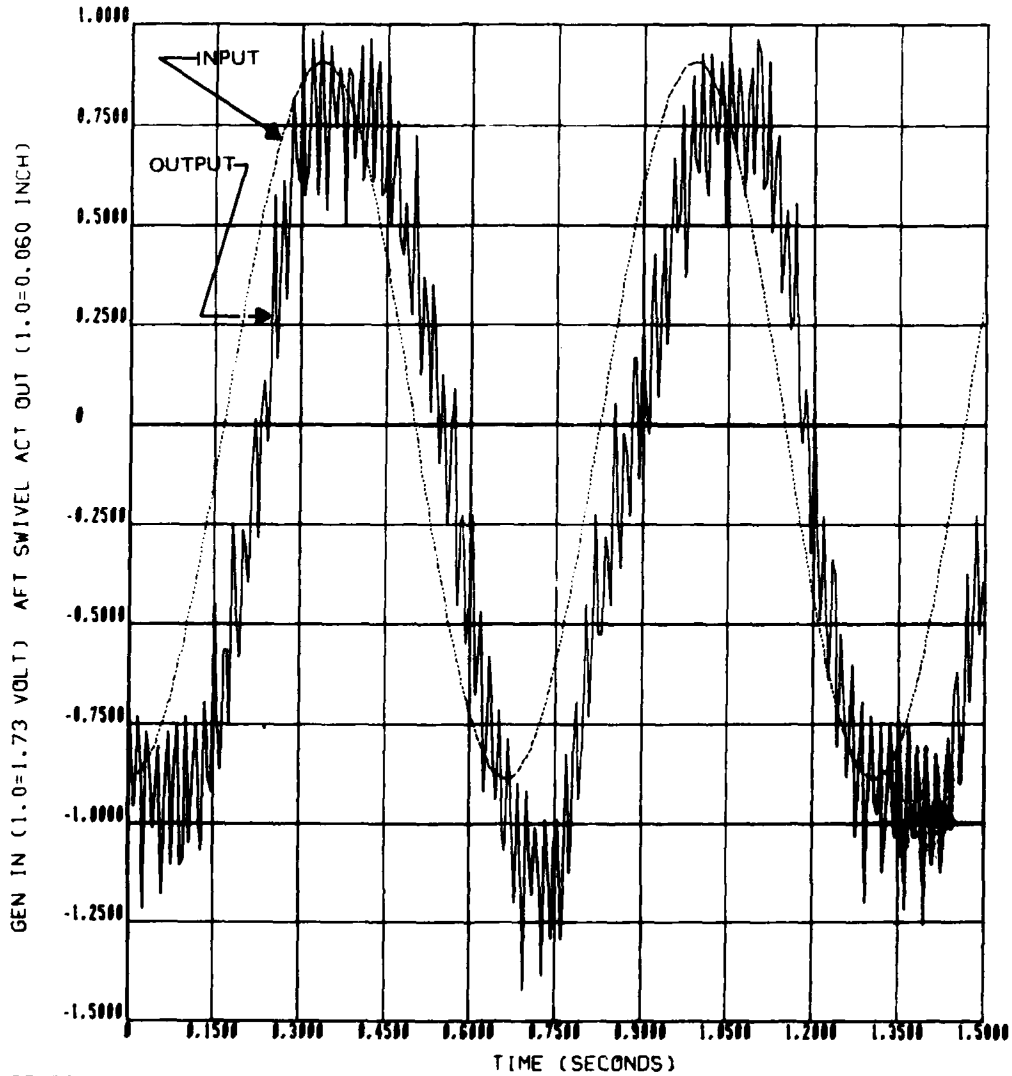
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈1.5 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
5. TIME SINCE ENGINE START -10 MINUTES



TZERO 0 20 36.008 P2340 FILE NO. 4 AND 6

FIGURE 94
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

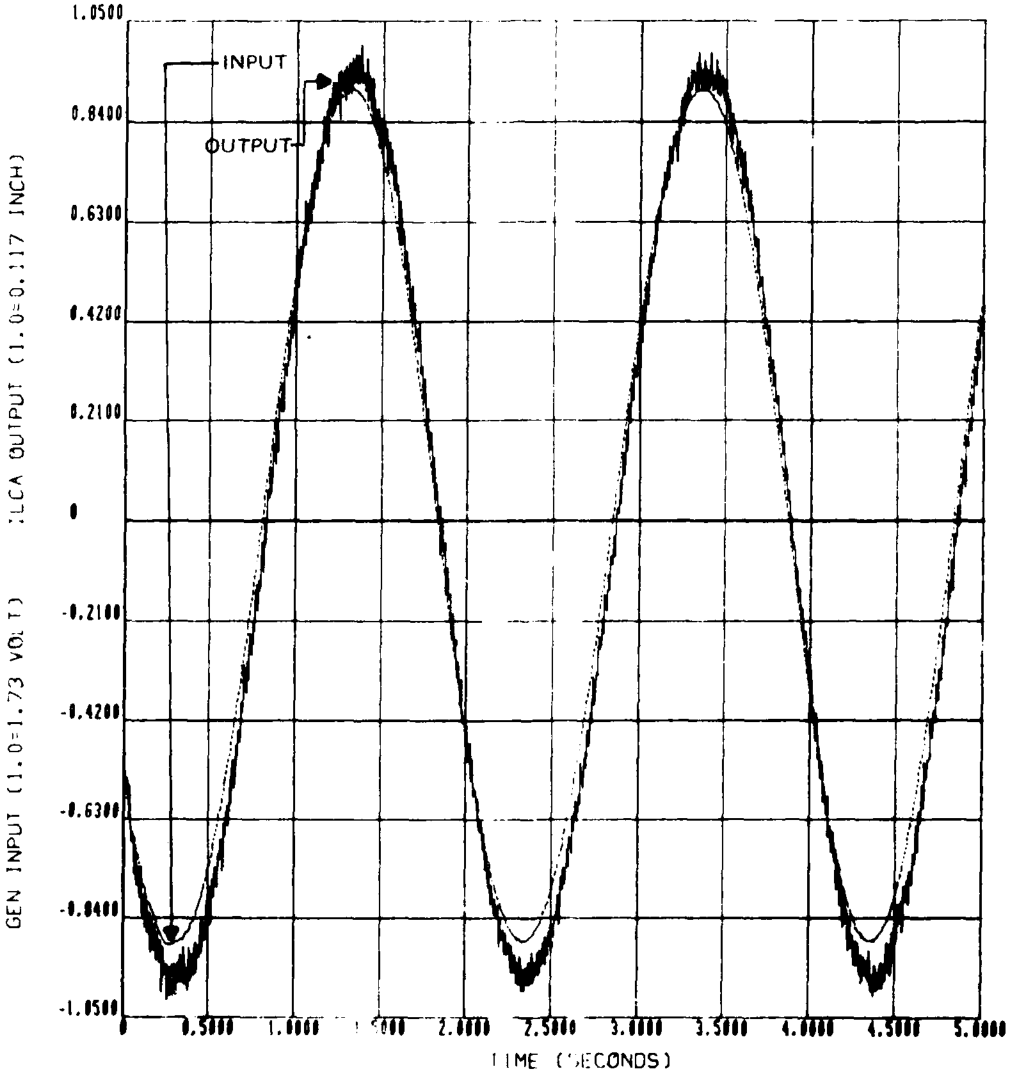
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈1.5 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
5. TIME SINCE ENGINE START - 10 MINUTES



TZERO 0 20 36.008 P2340 FILE NO. 5 AND 2

FIGURE 95
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

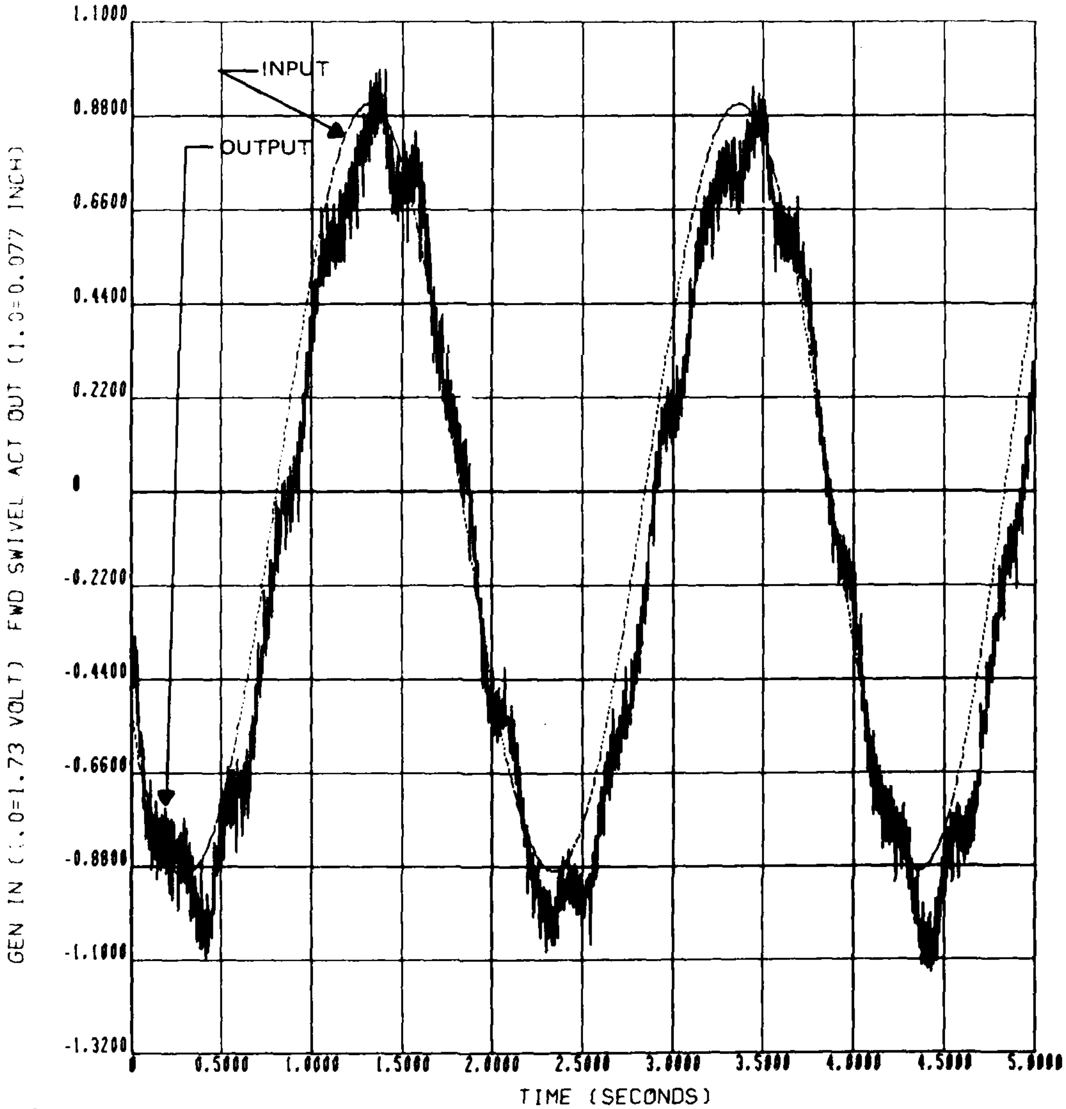
NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/ILCA OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.5 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
5. TIME SINCE ENGINE START - 10 MINUTES



TZERO 0 19 59.019 P2340 FILE NO. 3 AND 1

FIGURE 96
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTE:
1. TIME HISTORY PLOT - GENERATOR INPUT/FWD SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
3. FREQUENCY ≈0.5 HZ
4. NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
5. TIME SINCE ENGINE START - 10 MINUTES



TZERO 0 19 59.019 P2340 FILE NO. 4 AND 6

FIGURE 97
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES:
1. TIME HISTORY PLOT - GENERATOR INPUT/AFT SWIVELING ACT OUTPUT
2. HYDRAULIC SYSTEM SERVICED WITH MIL-83282 FLUID
3. FREQUENCY ≈0.5 HZ
4 NO. 1 RESERVOIR COOLER TEMPERATURE IN 70° C OUT 60° C
5. TIME SINCE ENGINE START - 10 MINUTES

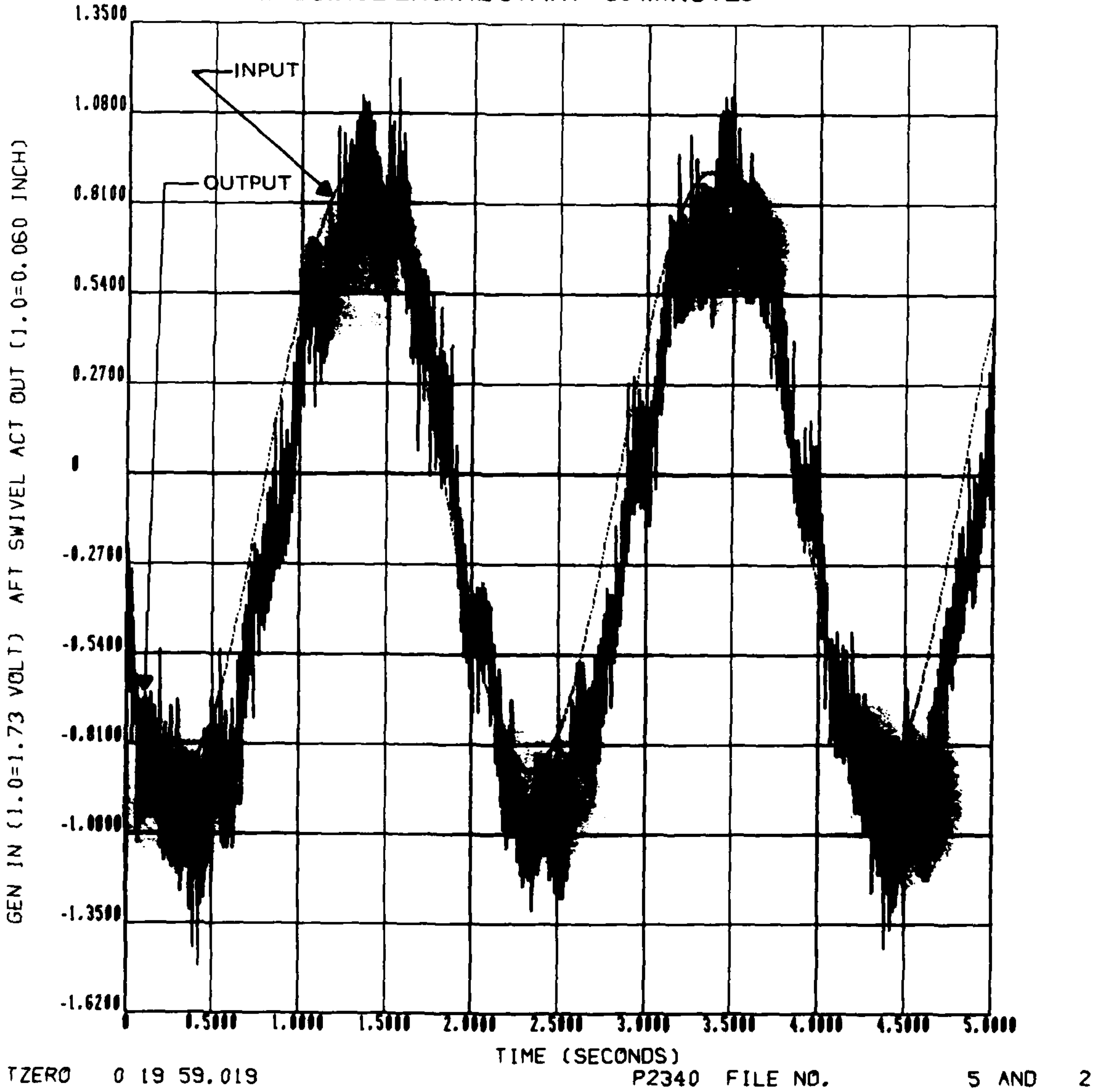
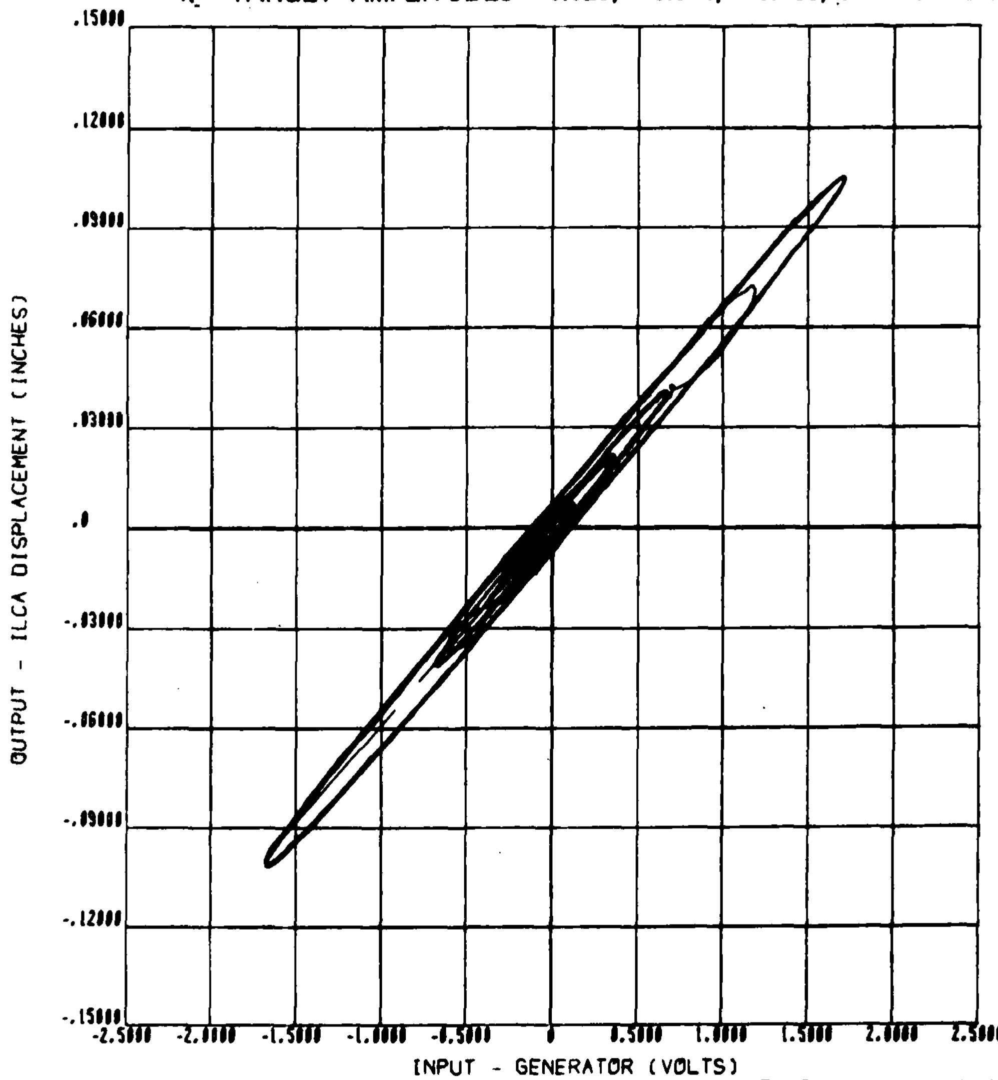


FIGURE 98
FLIGHT CONTROL SYSTEM RESPONSE
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -25° F
ILCA DISPLACEMENT

NOTES:
1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. NO. 1 RESERVOIR COOLER TEMPERATURE IN 5° C OUT -16° C
3. TARGET FREQUENCY 0.32 Hz
4. TARGET AMPLITUDES ±0.020, ±0.040, ±0.060, and ±0.125 IN.



TZERO 0 21 57.030 P2340 FILE NO. 1 AND 3

FIGURE 99

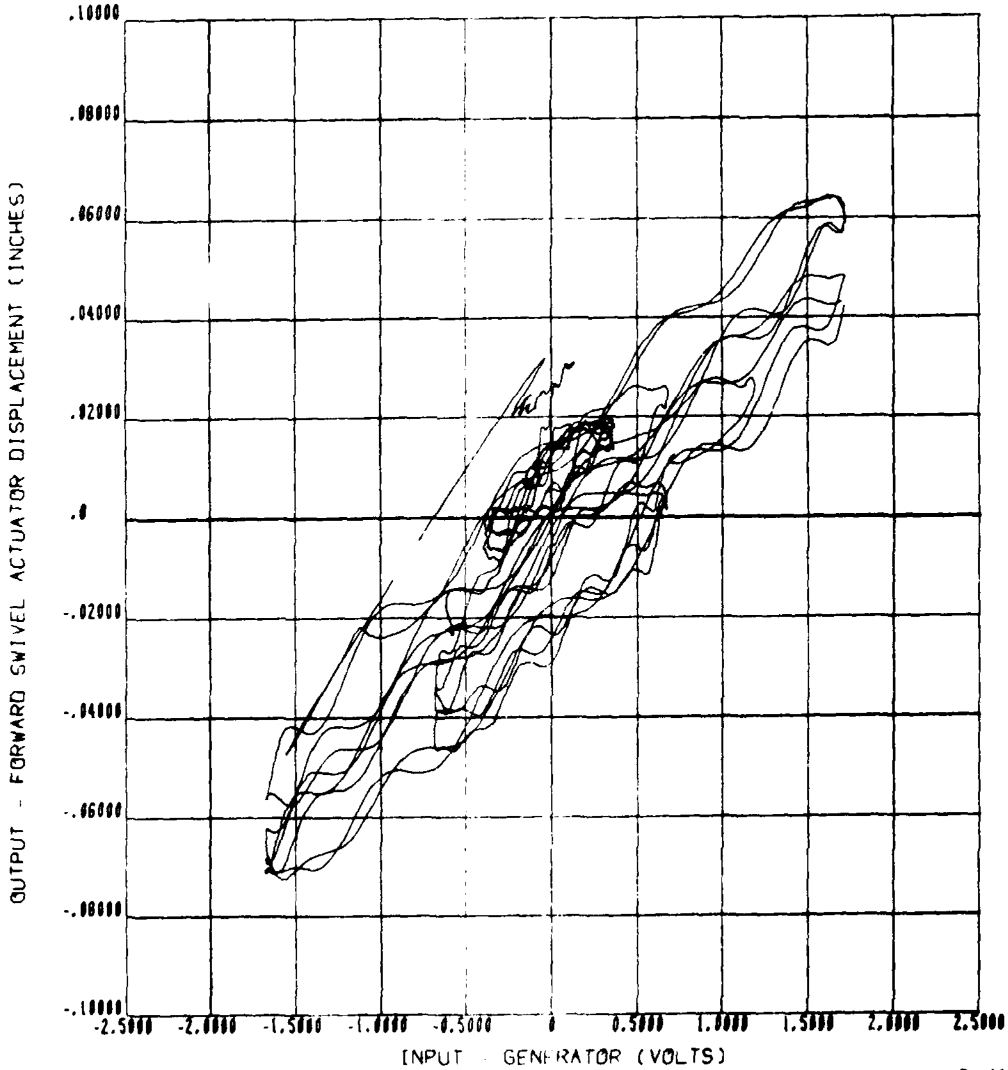
FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -25° F

FWD SWIVELING ACTUATOR DISPLACEMENT

NOTES:
1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. NO. 1 RESERVOIR COOLER TEMPERATURE IN 5° C OUT -16° C
3. TARGET FREQUENCY 0.32 Hz
4. TARGET AMPLITUDES ±0.020, ±0.040, ±0.060, and ±0.125 IN.



TZERO 0 21 57.030 P2340 FILE NO. 6 AND 4

FIGURE 100

FLIGHT CONTROL SYSTEM RESPONSE

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -25° F

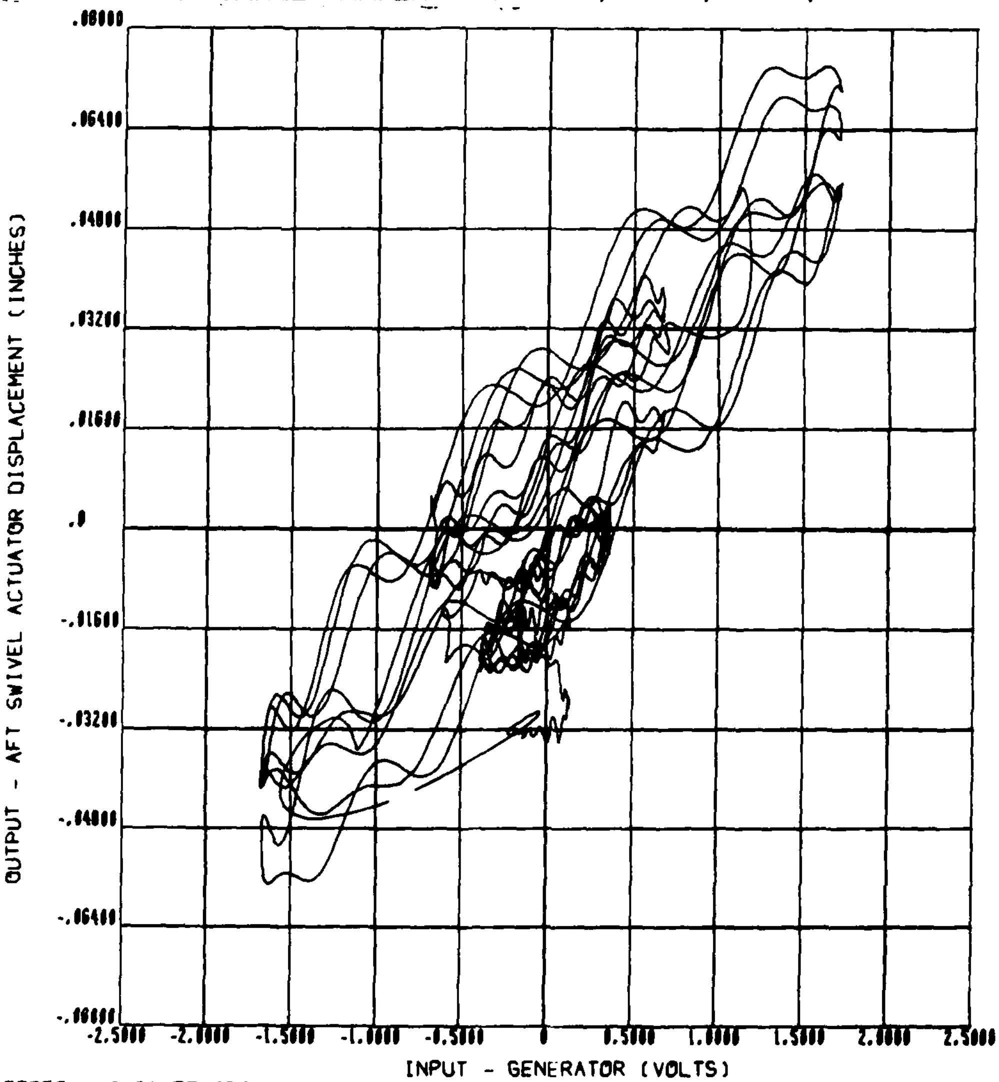
AFT SWIVELING ACTUATOR DISPLACEMENT

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

2. NO. 1 RESERVOIR COOLER TEMPERATURE IN 5° C OUT - 16° C

3. TARGET FREQUENCY 0.32 Hz

4. TARGET AMPLITUDES ±0.020, ±0.040, ±0.060, and ±0.125 IN.



TZERO 0 21 57.030 P2340 FILE NO. 2 AND 5

FIGURE 101

HYDRAULIC SYSTEM SURVEY

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

2. RUN ACCOMPLISHED SUBSEQUENT TO -65° F TESTING

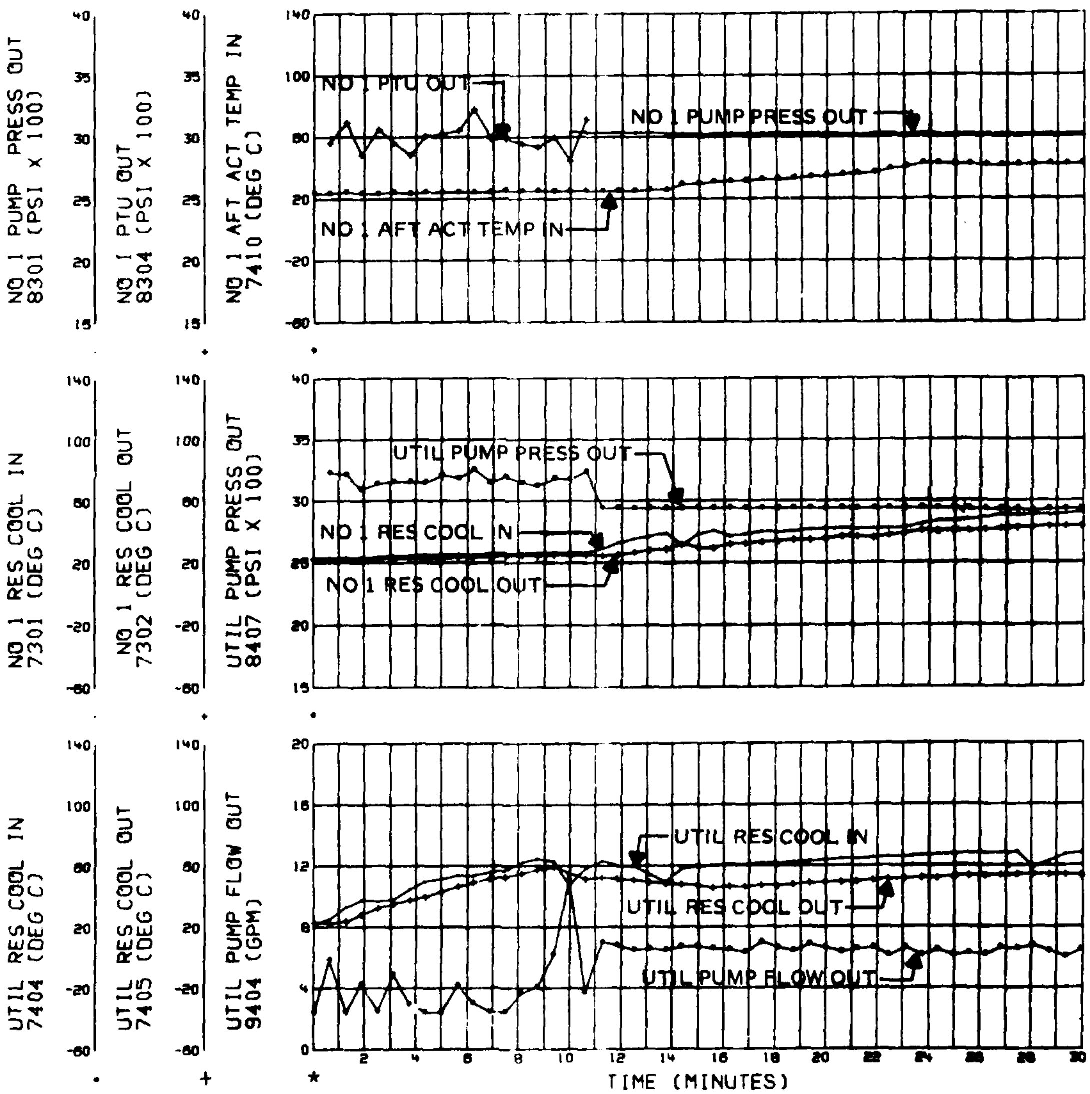


FIGURE 102
HYDRAULIC SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

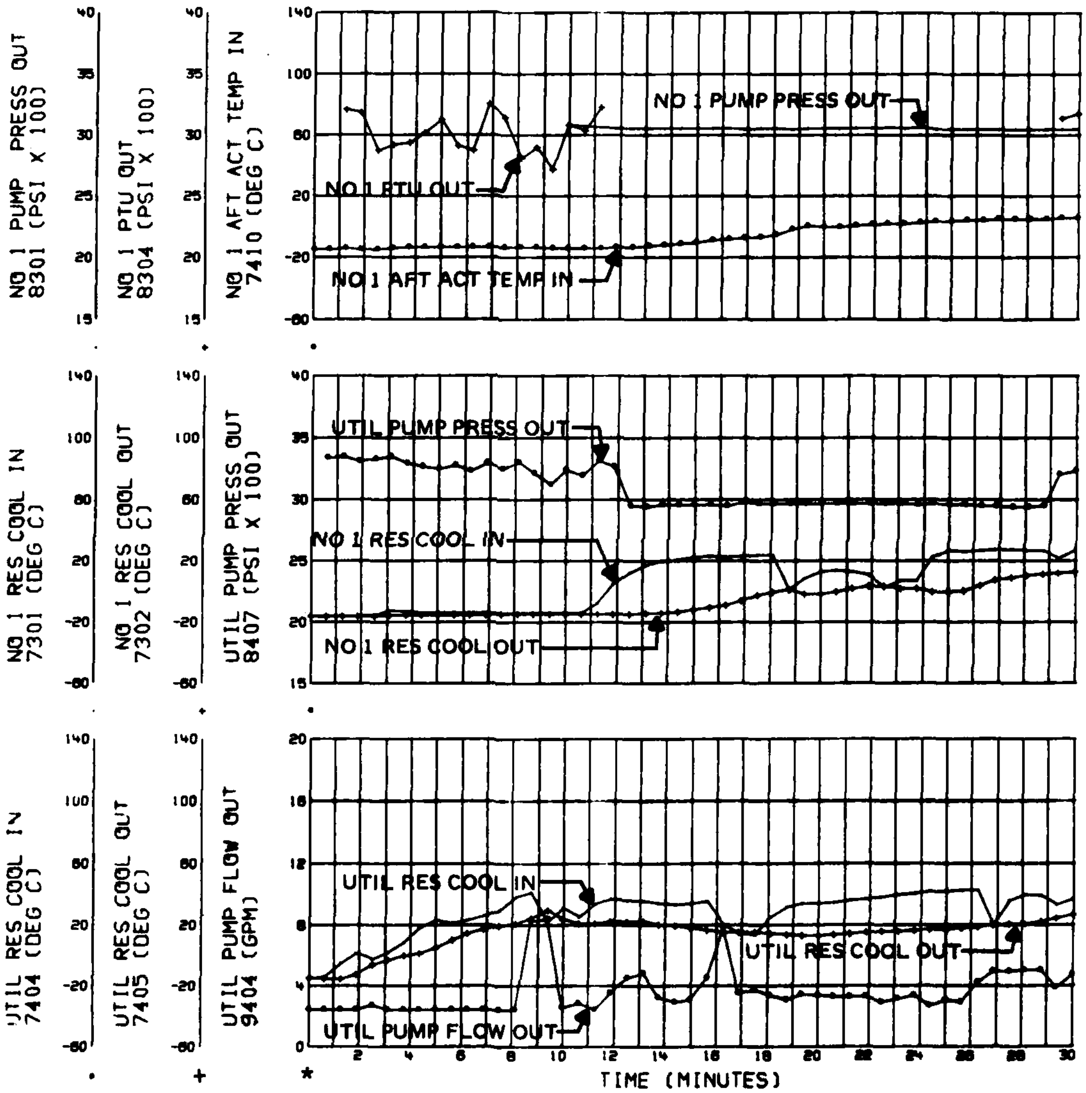


FIGURE 103
HYDRAULIC SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. ALL PARAMETERS DELETED FOR 3 MINUTES - INSTRUMENTATION NOISE

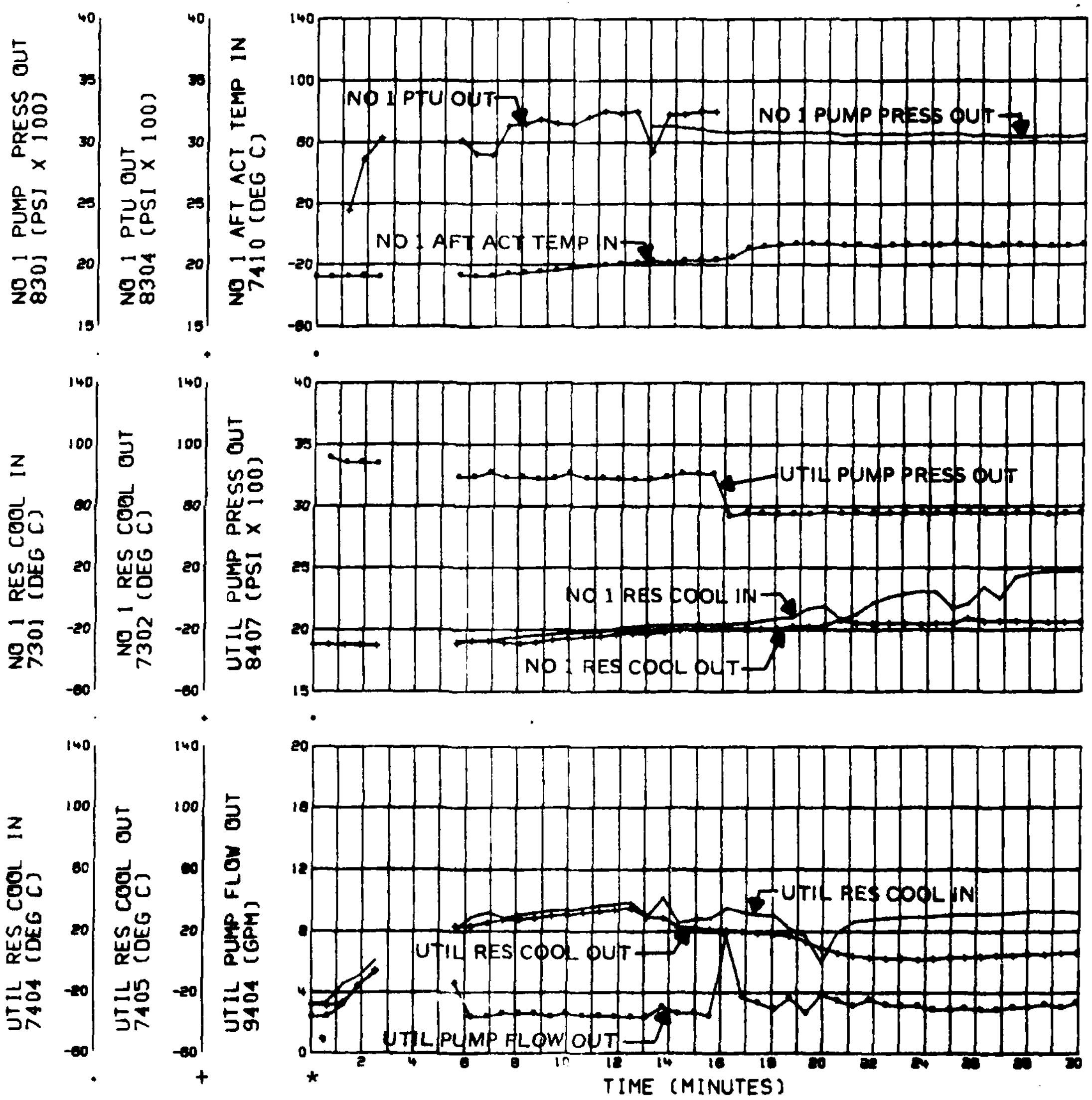


FIGURE 104
HYDRAULIC SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

2. DATA CONTINUED ON NEXT PAGE

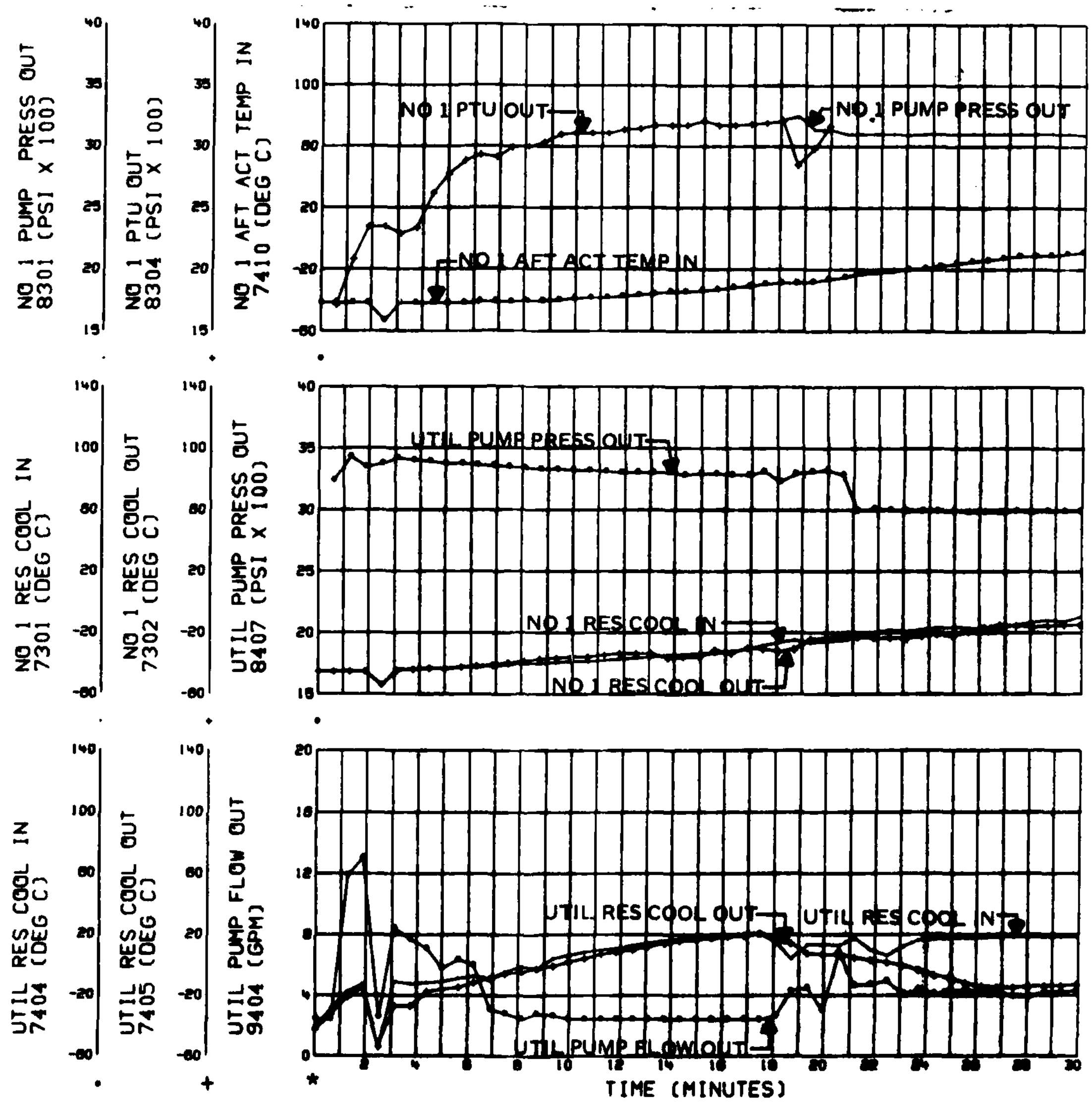


FIGURE 104 CONTINUED

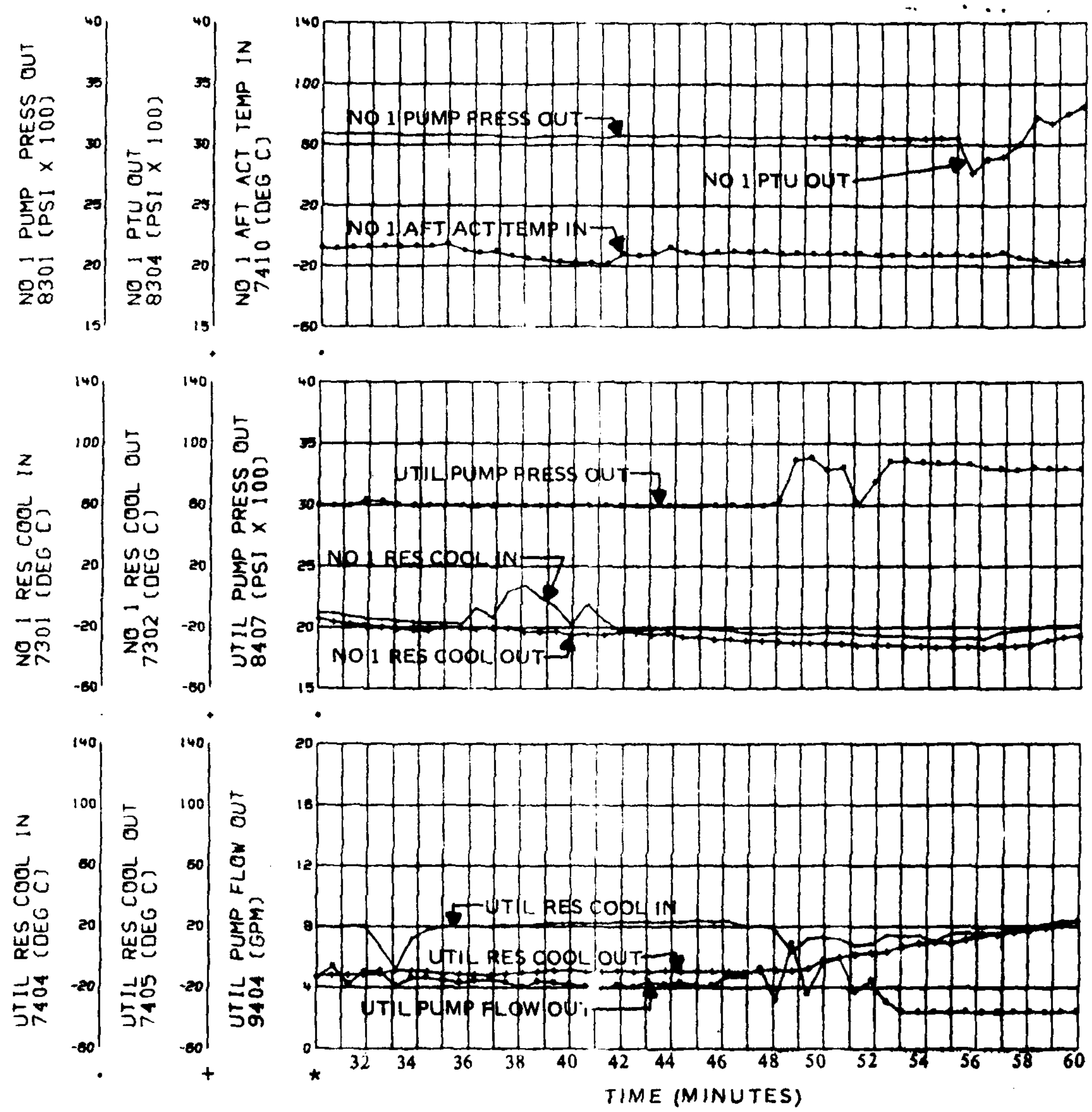


FIGURE 105
HYDRAULIC SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

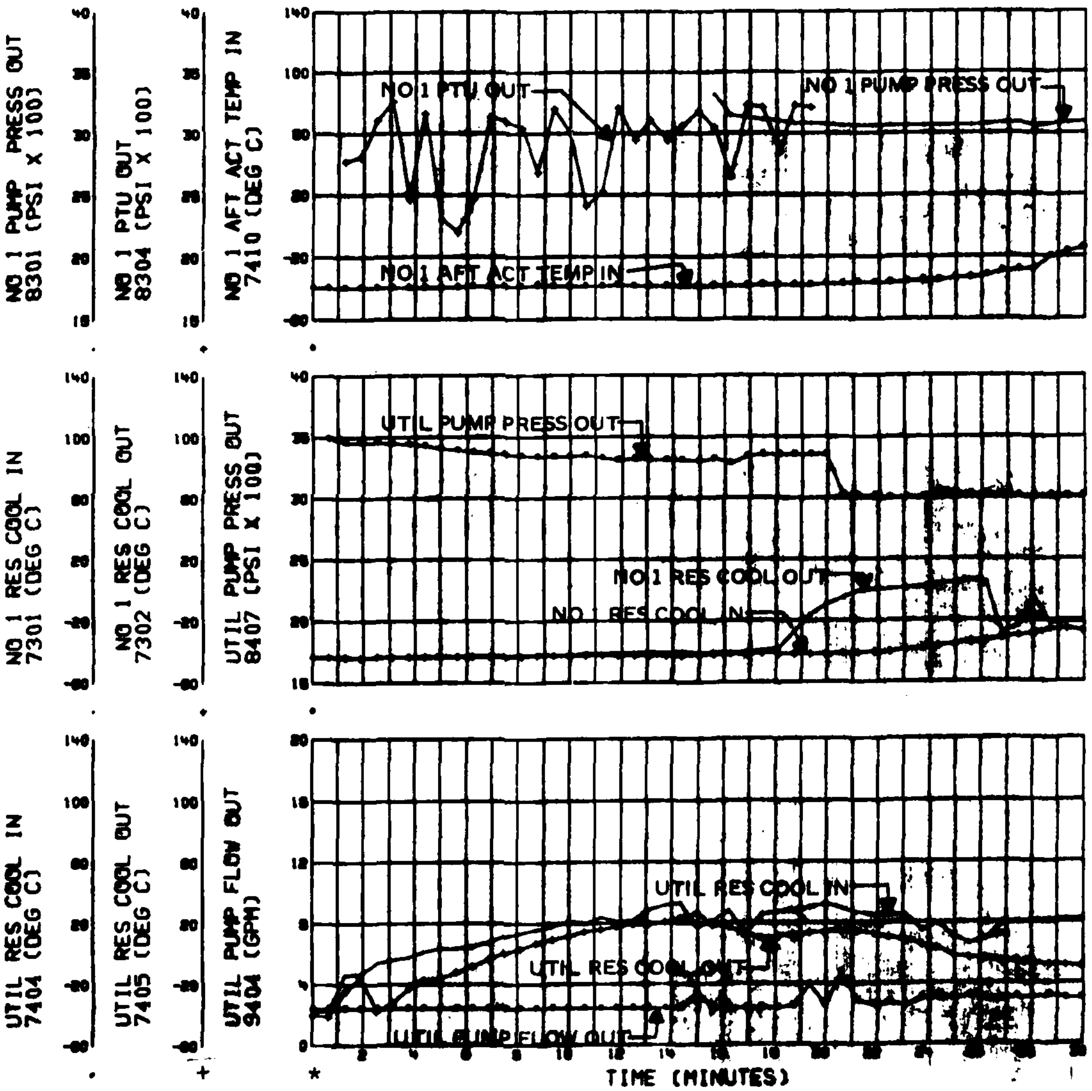


FIGURE 106

HYDRAULIC SYSTEM SURVEY

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES:
1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. THE PTU WAS ESSENTIALLY INOPERATIVE DURING THIS TEST
3. UTILITY PUMP FLOW INSTRUMENTATION UNRELIABLE
4. DATA CONTINUED ON NEXT PAGE

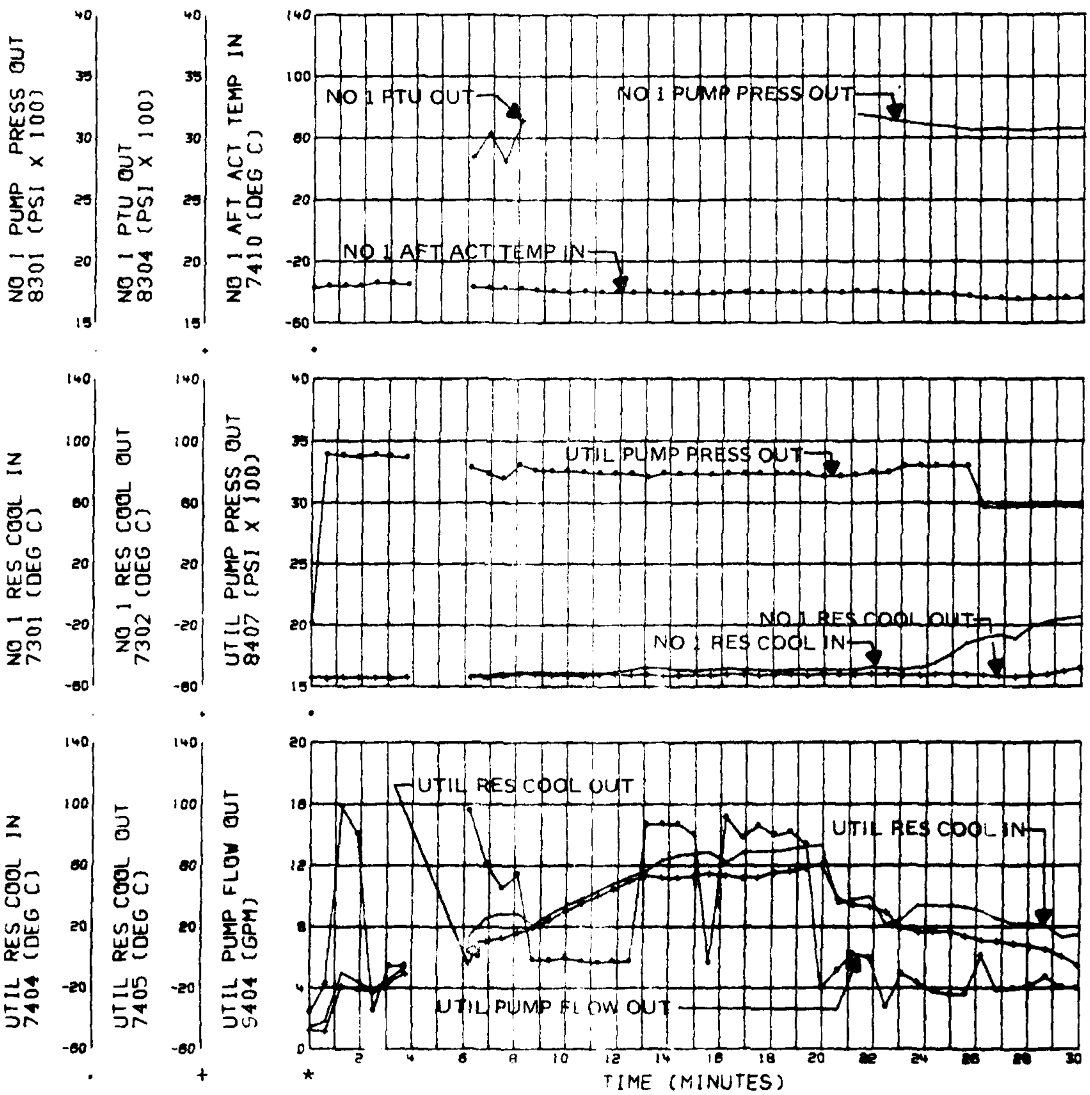


FIGURE 106 CONTINUED

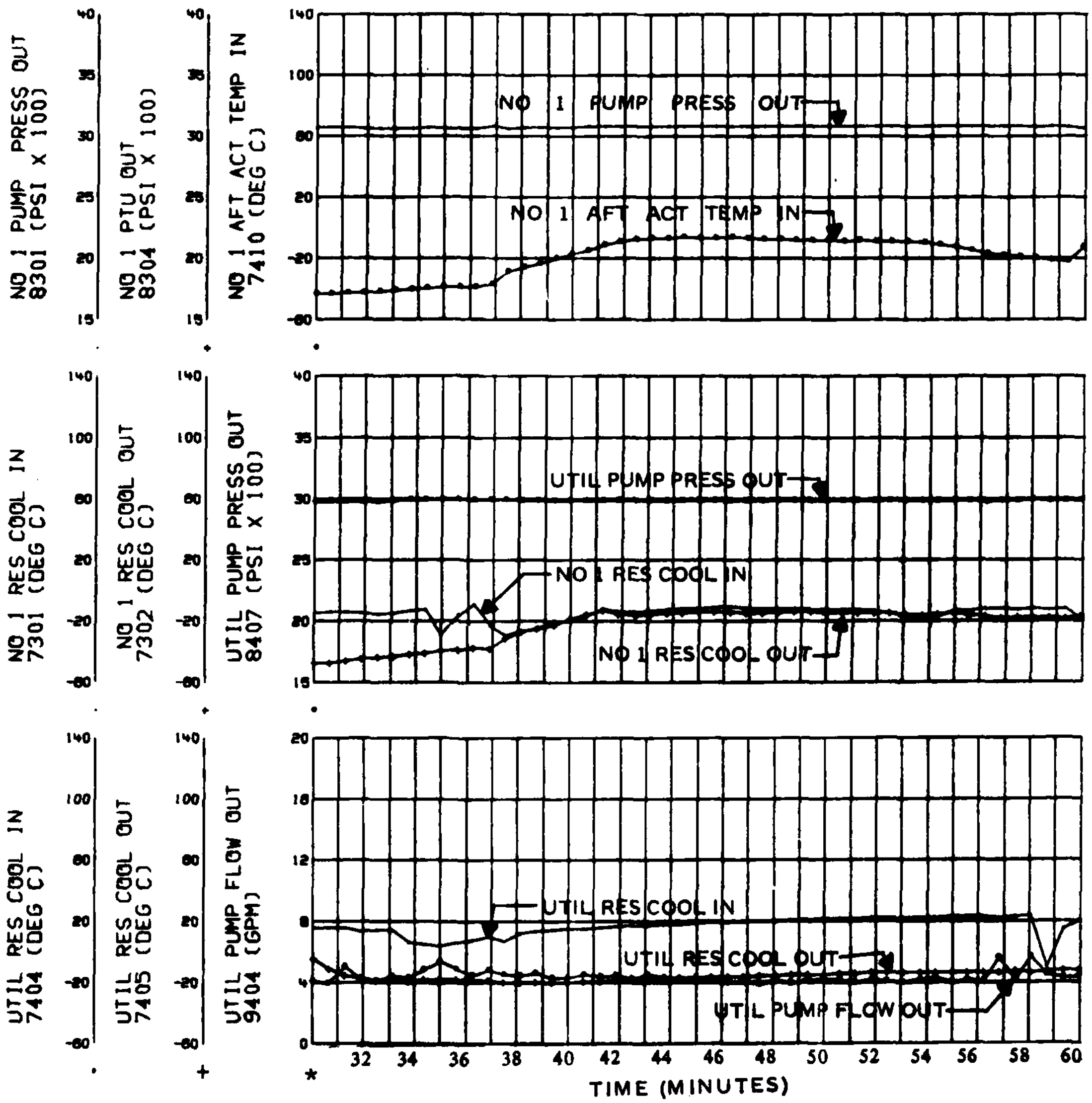
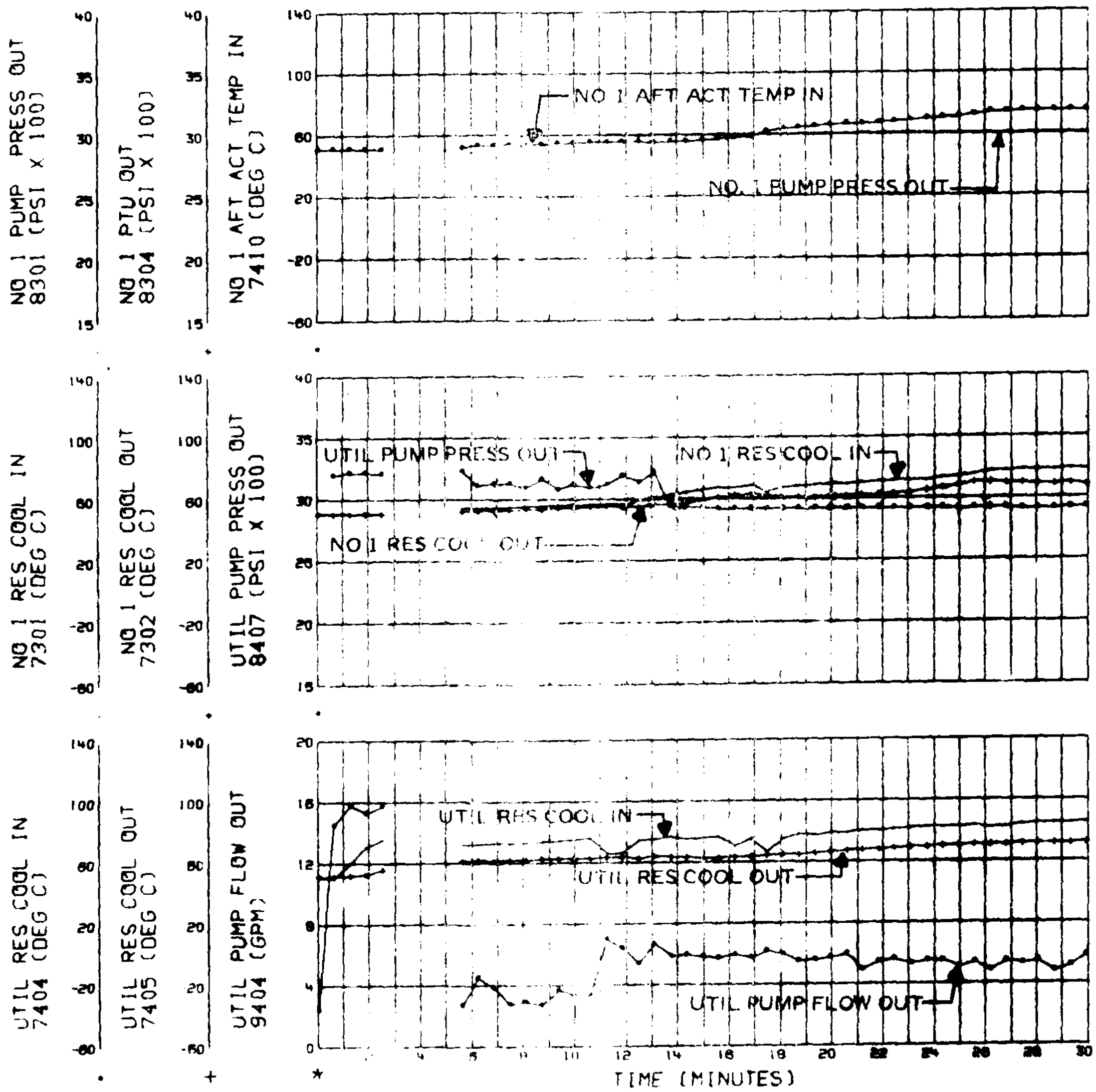


FIGURE 107
HYDRAULIC SYSTEM SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID
2. NO. 1 RESERVOIR COOLER TEMPERATURE APPROACHED 100° C WHEN FAN WAS DISABLED
3. NO. 1 PTU INSTRUMENTATION INOPERATIVE
4. DATA CONTINUED ON NEXT PAGE



AD-A115 861 ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB CA F/G 1/3
CLIMATIC LABORATORY EVALUATION YCH-47D HELICOPTER.(U)
AUG 81 J R NIEMANN, C F ADAM, J A BROWN

UNCLASSIFIED USAAEFA-79-13 NL

3 OF 3
AD
A115861

END
DATE
FILMED
7 82
DTIC

FIGURE 107 CONTINUED

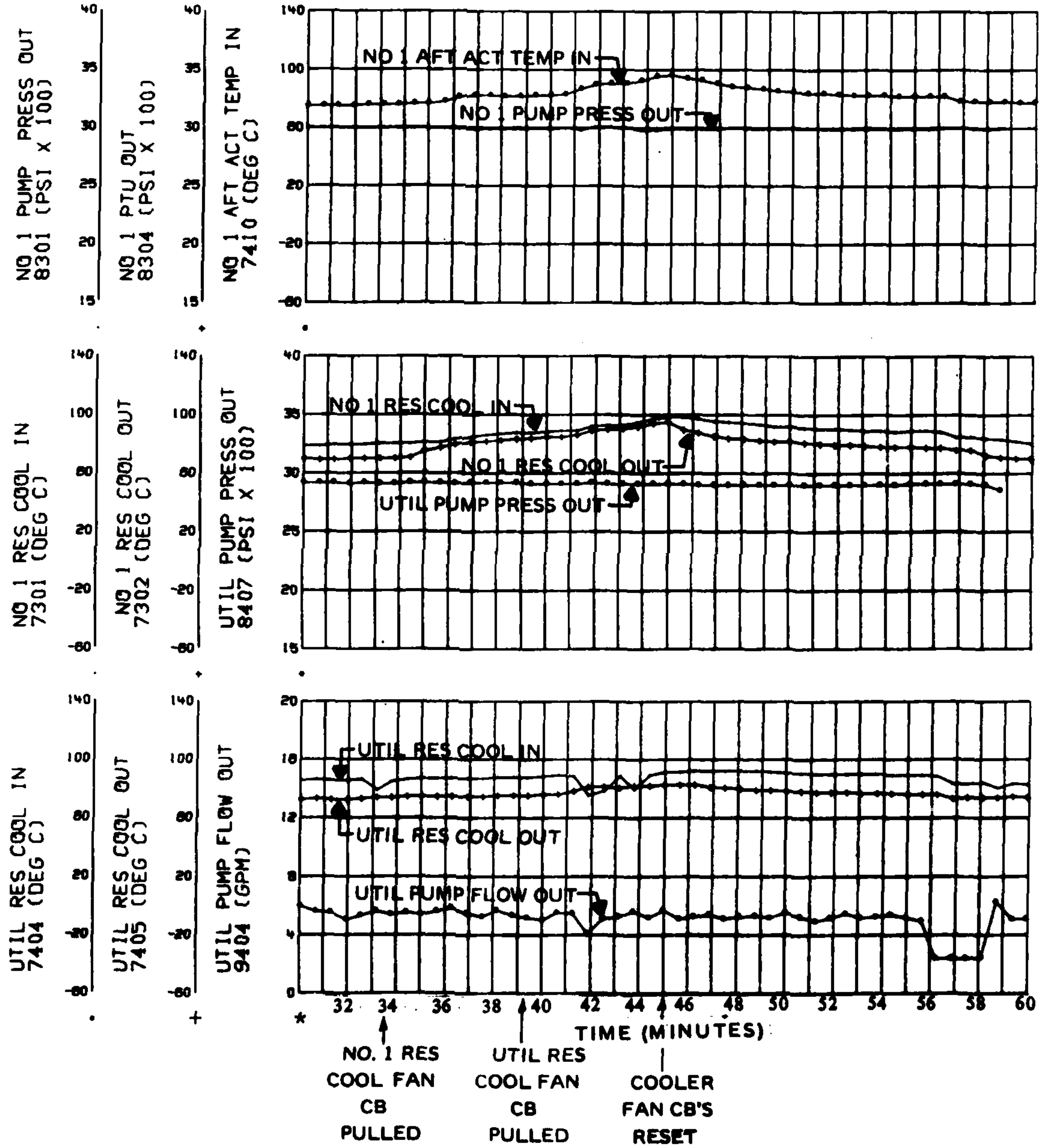


FIGURE 108

HYDRAULIC SYSTEM SURVEY

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282 FLUID

2. NO. 1 PTU DATA IS UNRELIABLE

3. NO. 1 RESERVOIR COOLER TEMPERATURES REACHED APPROXIMATELY 95° C WHEN THE FAN WAS DISABLED

4. DATA CONTINUED ON NEXT PAGE

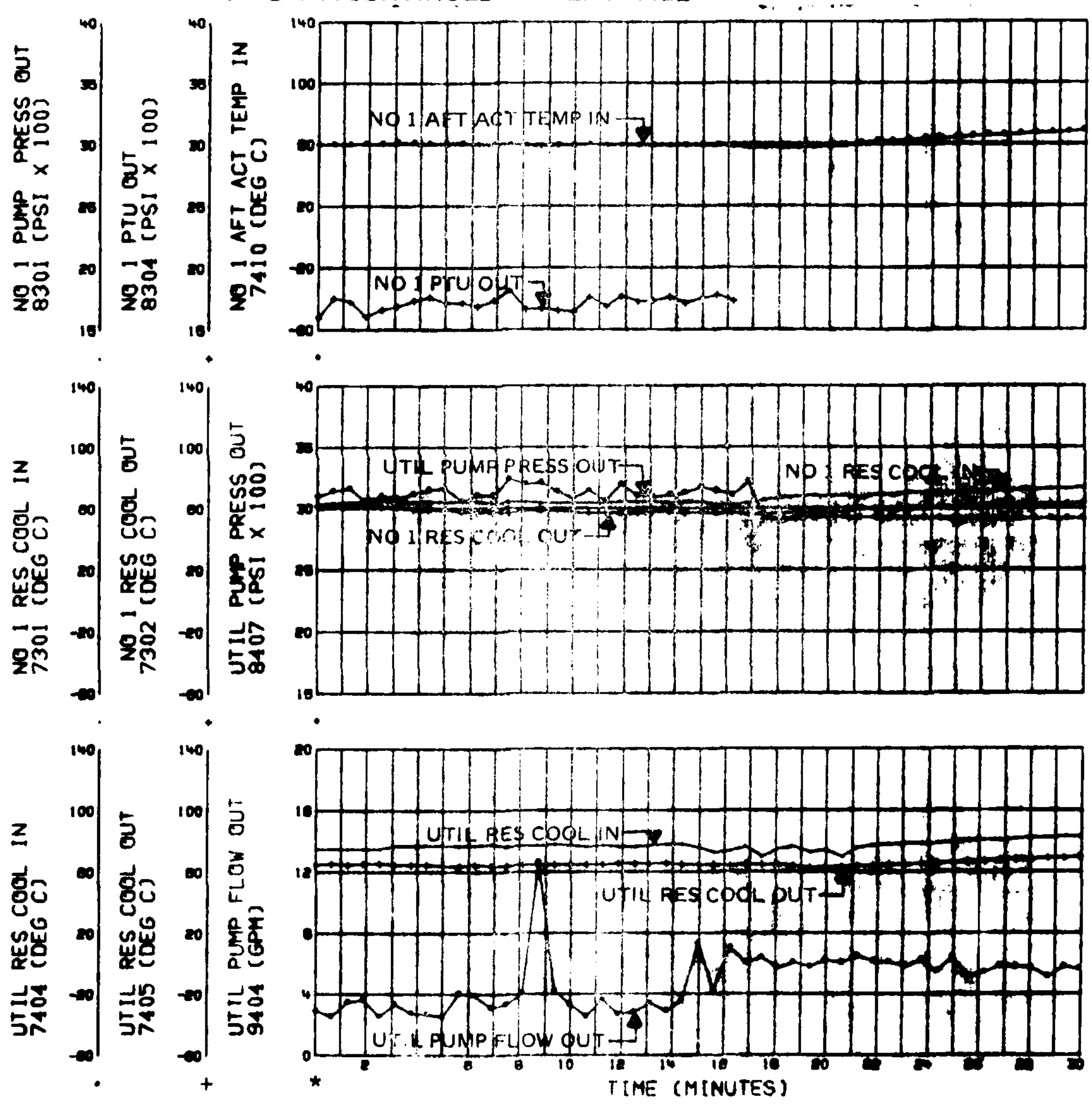


FIGURE 108 CONTINUED

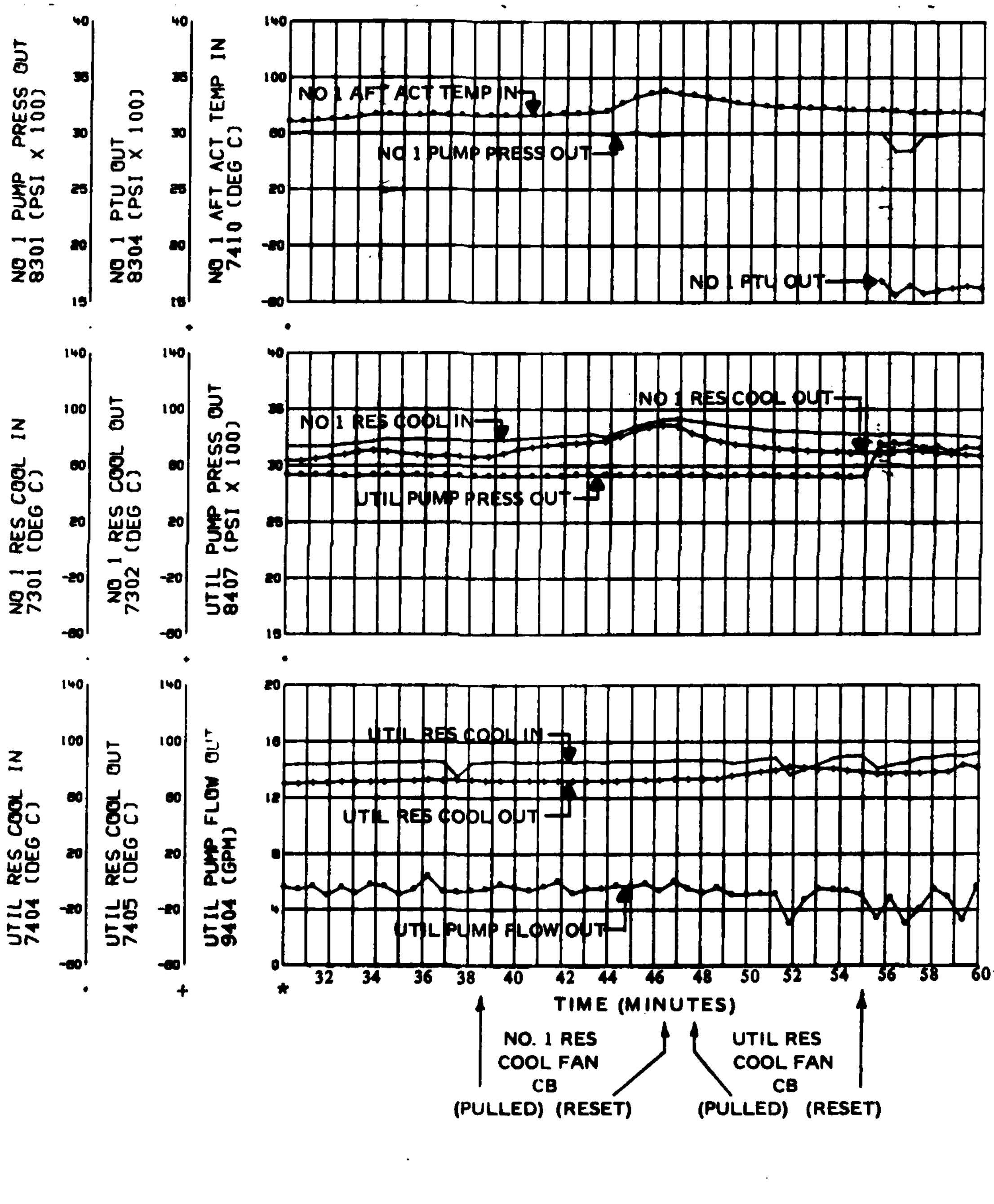


FIGURE 109
TRANSMISSION SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-23699 OIL
2. RUN ACCOMPLISHED SUBSEQUENT TO -65° F TESTING

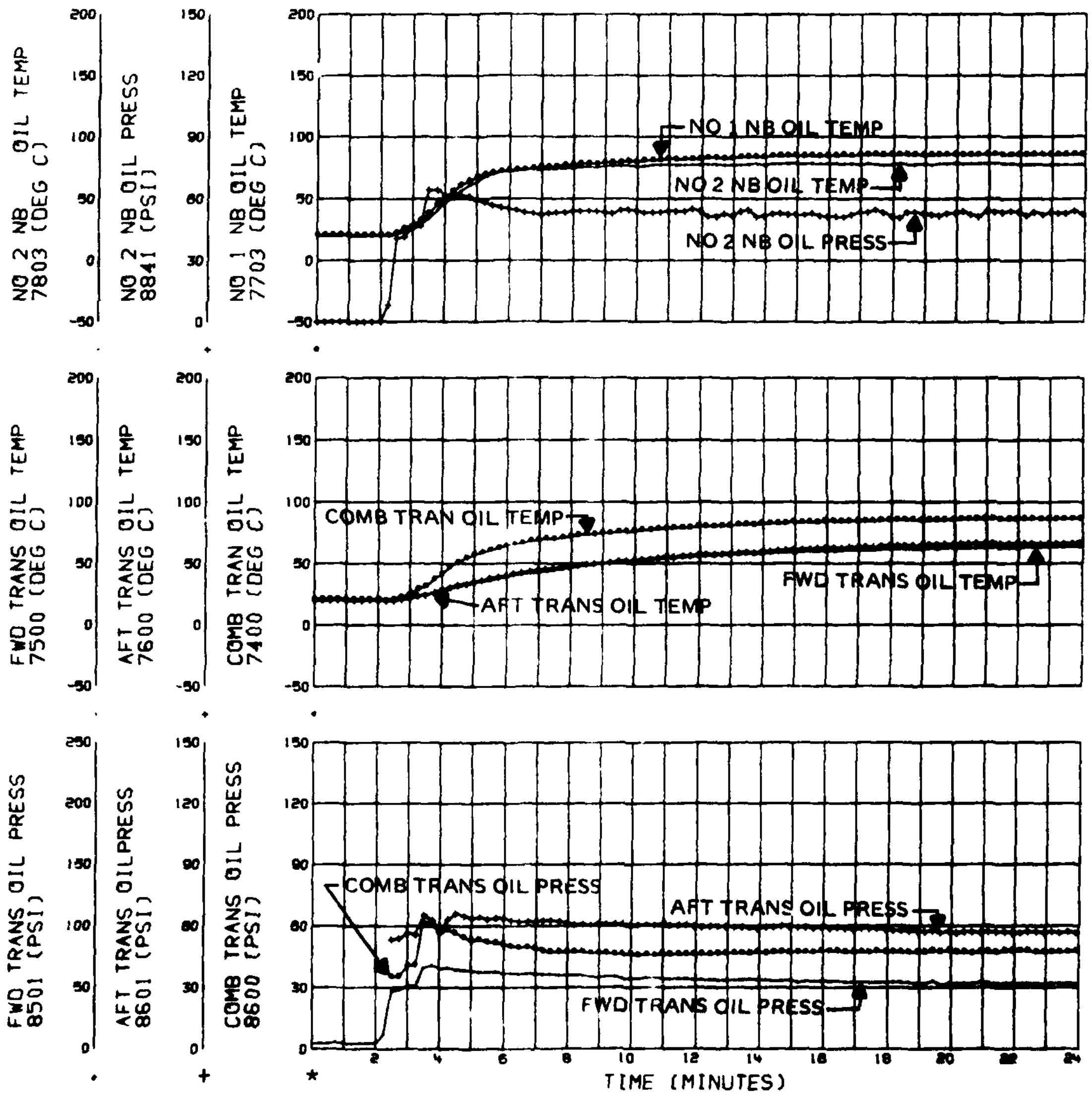


FIGURE 110
TRANSMISSION SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 0° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-23699 OIL

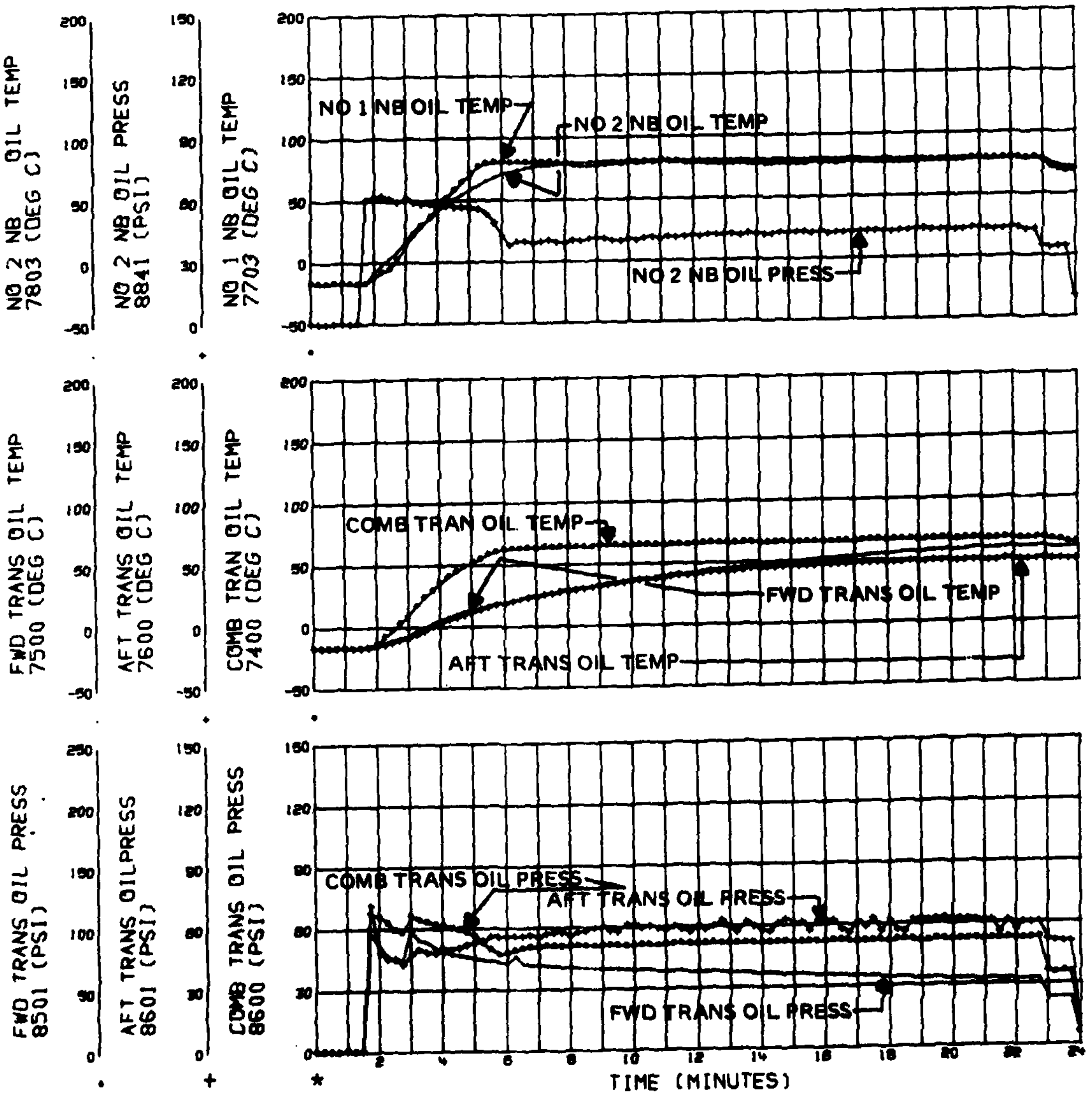


FIGURE 111

TRANSMISSION SURVEY

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -25° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-23699 OIL

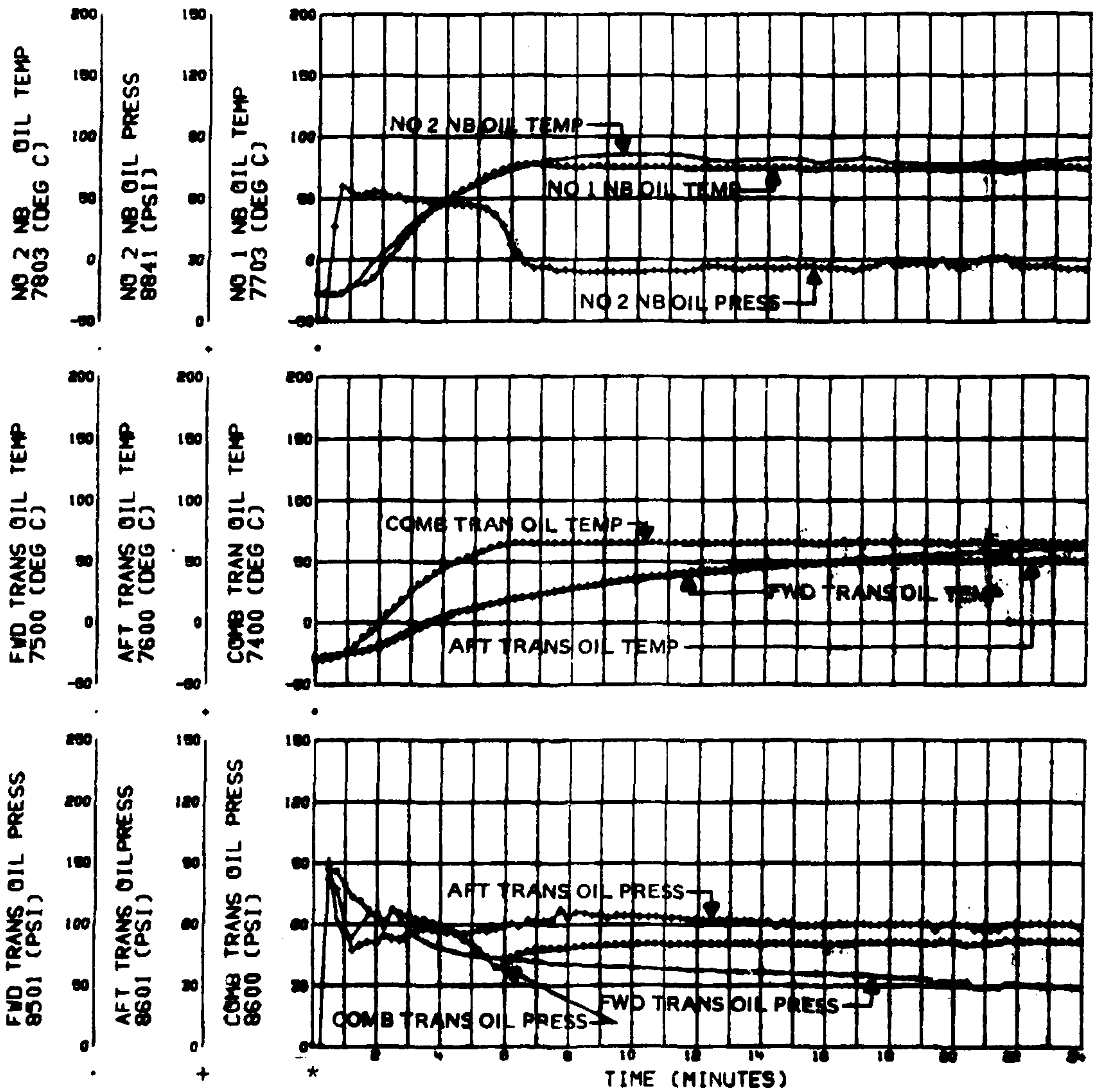


FIGURE 112
TRANSMISSION SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-7808 OIL

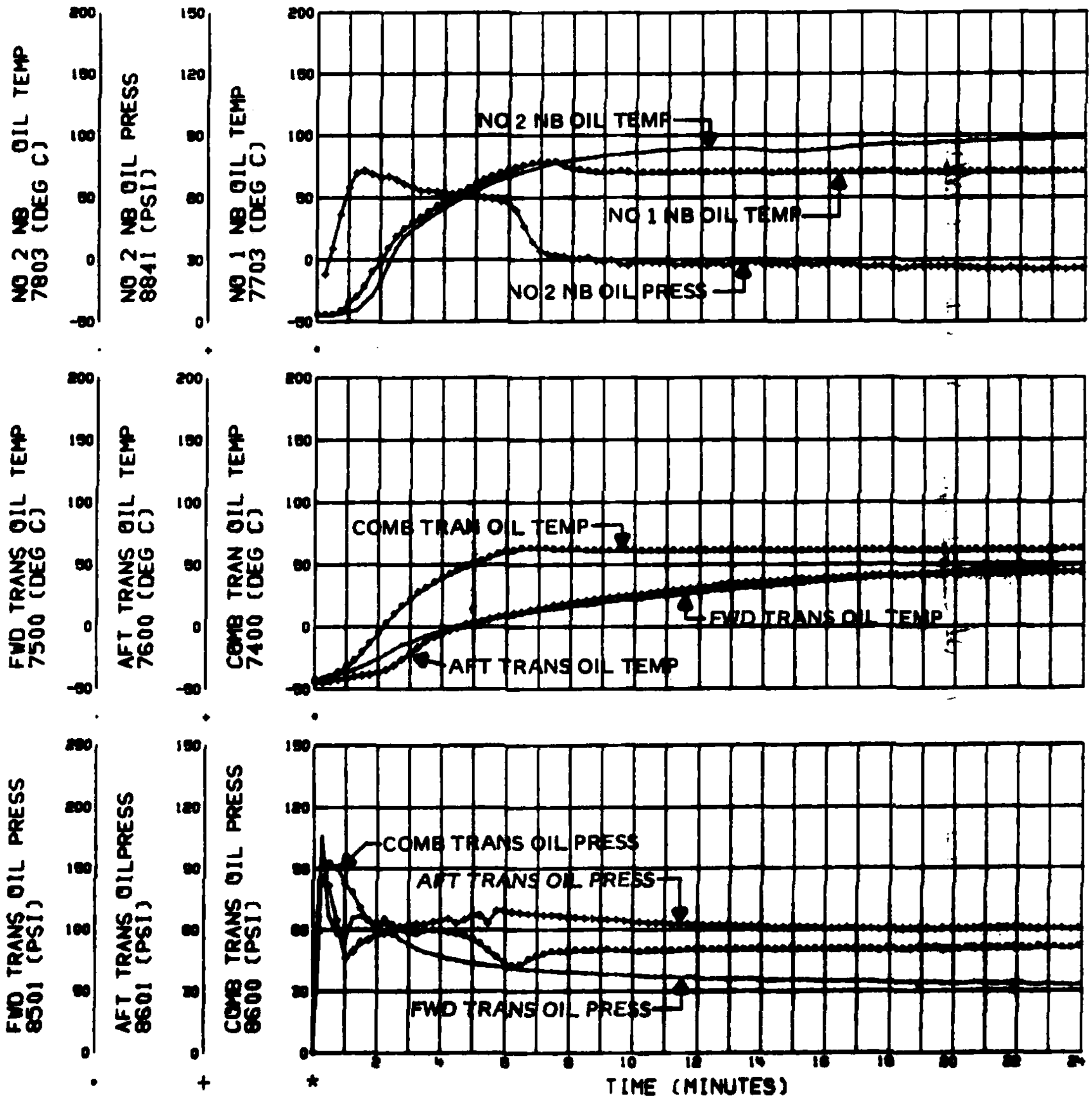


FIGURE 113
TRANSMISSION SURVEY
YCH-47D US ARMY S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-7808 OIL

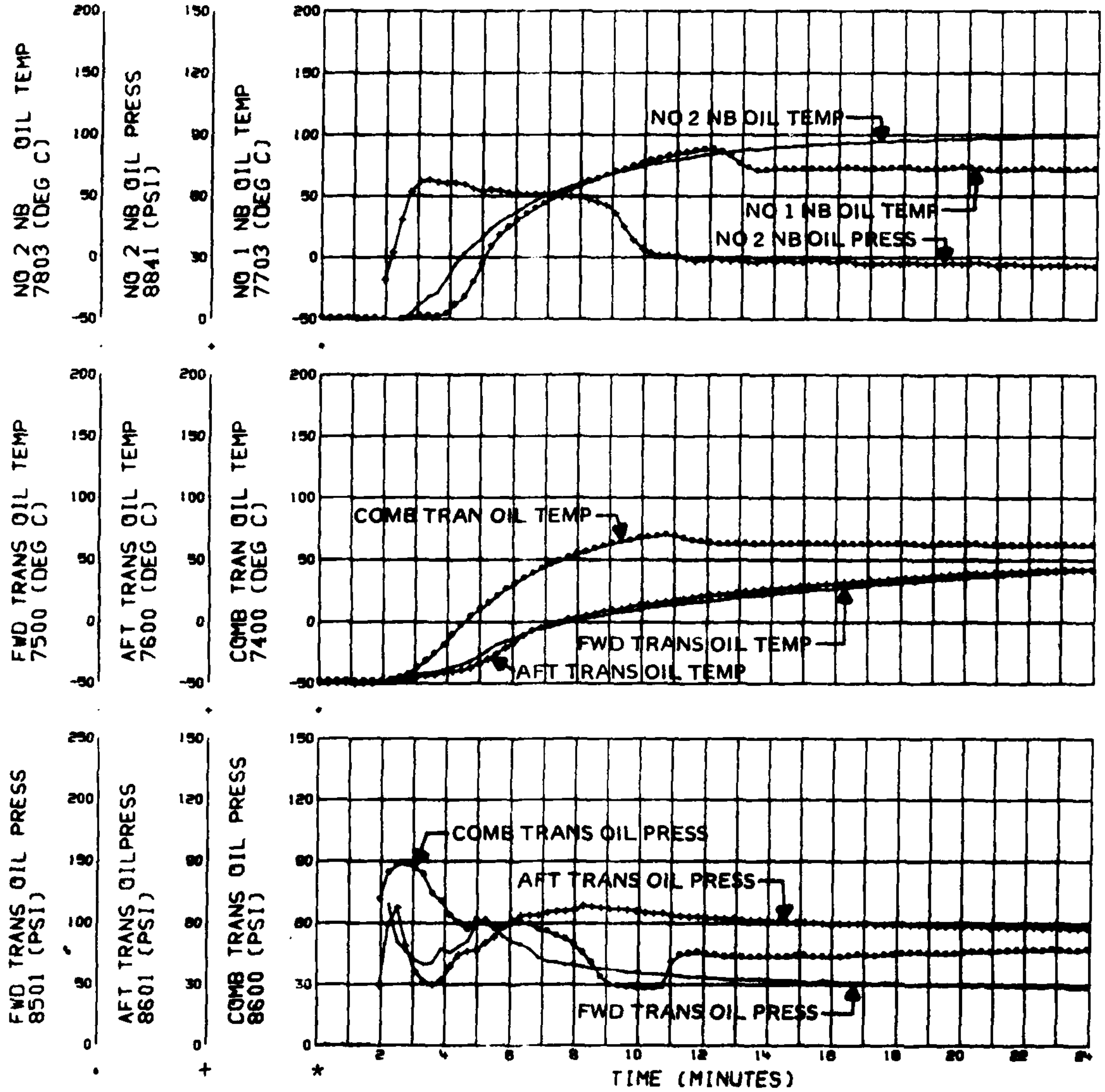


FIGURE 114

TRANSMISSION SURVEY DURING ENGINE START
YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE - 65° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-7808 OIL
2. FORWARD TRANSMISSION PRESSURE PEAKED 16 SECONDS AFTER ENGINE START SWITCH TO MOTOR

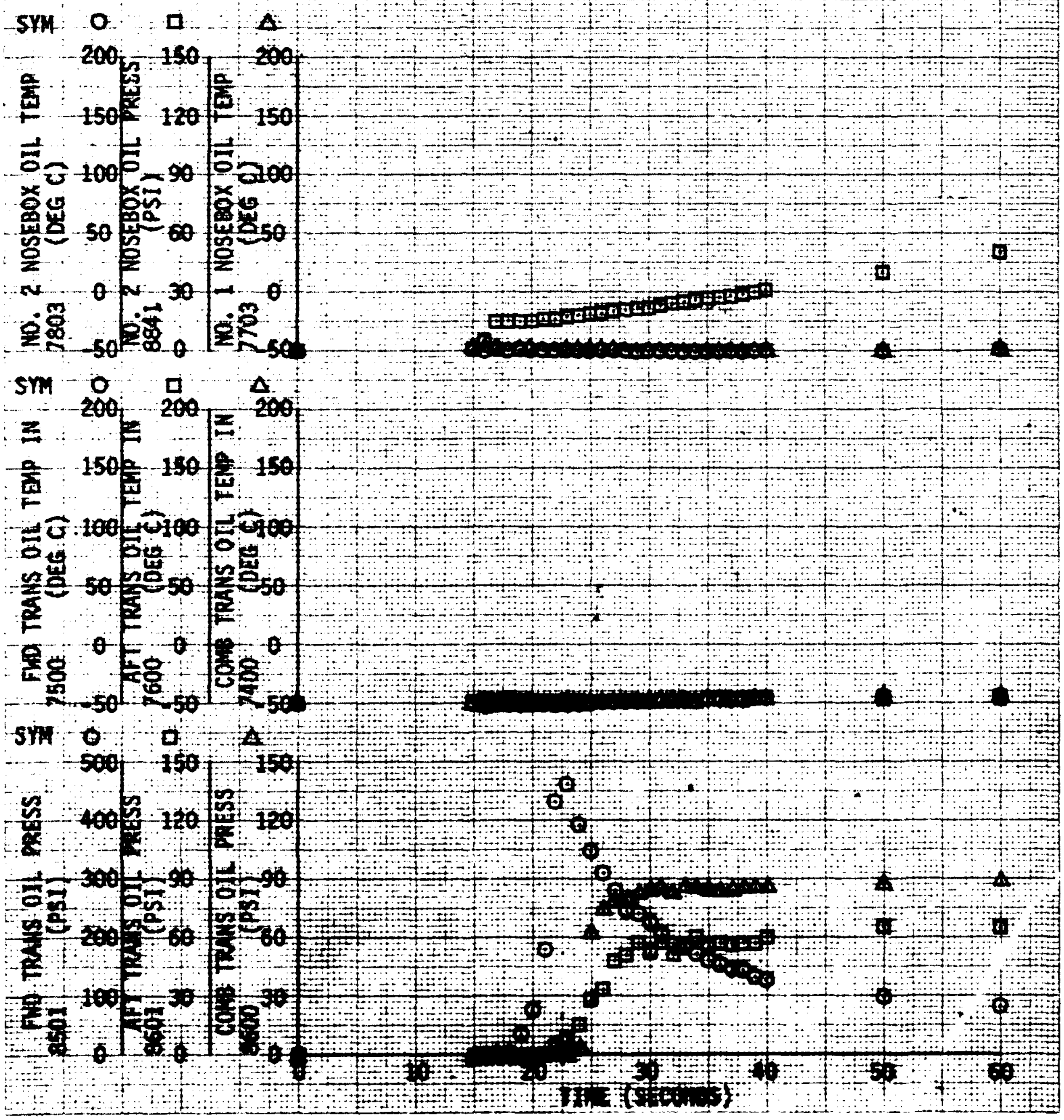


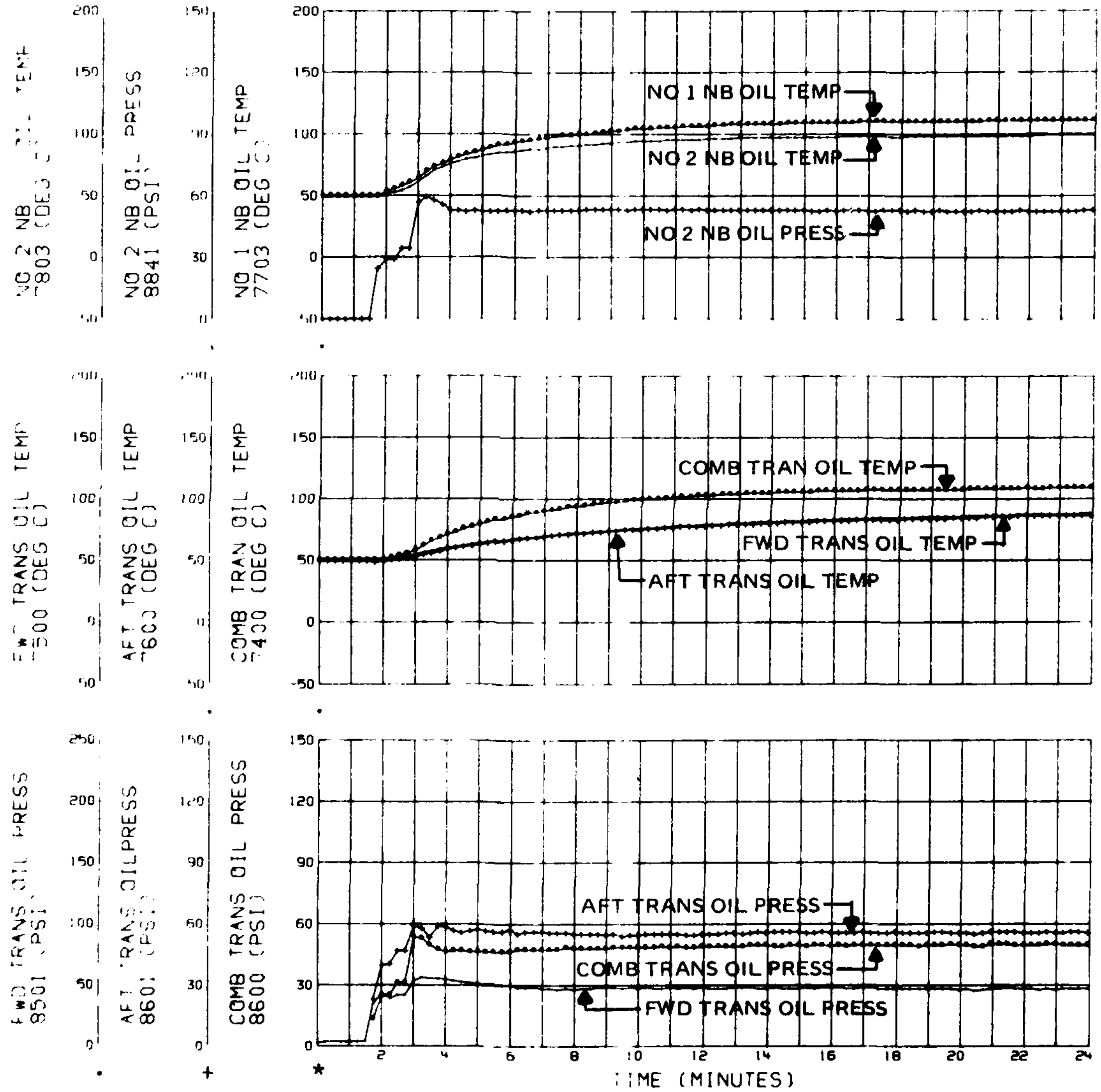
FIGURE 115

TRANSMISSION SURVEY

YCH-47D US ARMY S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE 125° F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-23699 OIL



APPENDIX F. SERVICING RECORD

Servicing information of the accumulator reservoirs, transmissions, engines and APU is also presented for runs 6 through 22 (tables 1-17).

TABLE 1

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE 0°F
RUN NO. 6

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1725-2100	1500	1850	3000 Syst Pressure	
APU Signal	1120-1300	1250		1250	
Power Steering	1120-1300	1200		1200	
#1 Flt Boost	1120-1300	950	1300	1300	
#2 Flt Boost	1120-1300	1200		1200	
Utility	1120-1300	No Data		No Data	
Brakes	600-850	800		1000	

Reservoirs					
#1 Flt Boost	Gr Band	Gr		Gr	
#2 Flt Boost	Gr Band	¼" above Gr Band		½" above Gr Band	
Utility	Gr Band	No Data		No Data	

Oil Levels					
Aft XMSN	Center of Glass	½ qt low		Generators removed	Added 2 qts
Fwd XMSN	Center of Glass	½ qt low		Center of Glass	
Comb XMSN	Line	Line		Line	
#1 Eng XMSN	Line	1 qt low		2 qts low	
#2 Eng XMSN	Line	2 qts low		1 qt low	
APU	DOT	No Data		No Data	
#1 Engine	"F" Line	"F" Line		½ qt high	
#2 Engine	"F" Line	"F" Line		⅓ qt high	

* 5 hrs after aircraft shutdown.

TABLE 2

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -25°F
RUN NO. 7

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post Run	Serviced To
APU Start	1775-2225	1550	1950	3000 Syst Pressure	
APU Signal	1060-1220	450	1225	3100 Syst Pressure	
Power Steering	1060-1220	1100		1200	
#1 Flt Boost	1060-1220	1150		1200	
#2 Flt Boost	1060-1220	1075		1150	
Utility	1060-1220	450	1200	3000 Syst Pressure	
Brakes	600-850	650		1150 Syst Pressure	

Reservoirs					
#1 Flt Boost	Gr Band	1/16"above Gr Band		1/16"above Gr Band	
#2 Flt Boost	Gr Band	¼"above Gr Band		3/8" above Gr Band	
Utility	Gr Band	Low	Indicator Inop.	Low	

Oil Levels					
Aft XMSN	Center of Glass	1 qt low		None in Glass	
Fwd XMSN	Center of Glass	2 qts low		½ qt low	
Comb XMSN	Line	Line		Line	
#1 Eng XMSN	Line	1 qt low		1 qt low	1 qt to line
#2 Eng XMSN	Line	1½ qts low		Line	
APU	DOT	No Data		No Data	
#1 Eng	"F" Line	"F" Line		"F" Line	
#2 Eng	"F" Line	"F" Line		"F" Line	

TABLE 3

SERVICING RECORD

YCH-47D USA S/N 76-8808
CLIMATIC LABORATORY TEMPERATURE -25°F
RUN NO. 8

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1775-2225	1950		1950	
APU Signal	1060-1220	500	1200	550	1200
Power Steering	1060-1220	1220		600	1200
#1 Flt Boost	1060-1220	1200		1400	
#2 Flt Boost	1060-1220	1150		1400	
Utility	1060-1220	1200		1200	
Brakes	600-850	825		850	
Reservoirs					
#1 Flt Boost	Gr Band	Gr		Gr	
#2 Flt Boost	Gr Band	3/16"above Gr Band		Gr	
Utility	Gr Band	Gr		Gr	
Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		2 qts low	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	1 qt Overfull		2¼ qts Overfull	
#1 Eng XMSN	Line	½ qt low		On Line	
#2 Eng XMSN	Line	½ qt Overfull		1 qt Overfull	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	"F" Line		"F" Line	
#2 Eng	"F" Line	"F" Line		"F" Line	

* 30 minutes after aircraft shutdown.

TABLE 4

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -25°F
RUN NO. 9

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1775-2225	1900		1950	
APU Signal	1060-1220	400	1200	450	
Power Steering	1060-1220	1200		1200	
#1 Flt Boost	1060-1220	1200		1250	
#2 Flt Boost	1060-1220	1200		1150	
Utility	1060-1220	1100		1220	
Brakes	600-850	700		750	

Reservoirs					
#1 Flt Boost	Gr Band	Gr Band		Gr Band	
#2 Flt Boost	Gr Band	Gr Band		1/8" above Gr Band	
Utility	Gr Band	Gr Band		1/8" above Gr Band	

Oil Levels					
Aft XMSN	Center of Glass	½ qt low		26 qts Added (1	Center of Glass
Fwd XMSN	Center of Glass	¼ qt low		23 qts Added (1	Center of Glass
Comb XMSN	Line	1 qt Overfull		16 qts Added (1	Line
#1 Eng XMSN	Line	½ qt low		16 qts Added (1	Line
#2 Eng XMSN	Line	Line		6 qts Added (1	Line
APU	DOT	DOT		3 qts Added (1	DOT
#1 Eng	"F" Line	1 pt above "F"		13 qts Added (1	"F" Line
#2 Eng	"F" Line	1 pt above "F"		13 qts Added (1	"F" Line

(1 The oil was changed from MIL-L-23699 to MIL-L-7808 following this run at -25°F.

TABLE 5

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50°F
RUN NO. 10

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1950-2100	1500	2000	2200	
APU Signal	1020-1180	300	1050	600	
Power Steering	1020-1180	950	1200	600	
#1 Flt Boost	1020-1180	950		300	
#2 Flt Boost	1020-1180	1150		1300	
Utility	1020-1180	350	1200	300	
Brakes	600-850	500	850	850	

Reservoirs					
#1 Flt Boost	Gr Band	Gr Band		Gr Band	
#2 Flt Boost	Gr Band	Gr Band		Gr Band	
Utility	Gr Band	Gr Band		Low	Serviced to Gr Band

Oil Levels					
Aft XMSN	Center of Glass	2 qts Low	2 qts Added	NOT OPERATED	
Fwd XMSN	Center of Glass	4 qts Low	4 qts Added	NOT OPERATED	
Comb XMSN	Line	Line		NOT OPERATED	
#1 Eng XMSN	Line	1 qt Low	1 qt Added	NOT OPERATED	
#2 Eng XMSN	Line	2 qts Low	2 qts Added	NOT OPERATED	
APU	DOT	DOT			
#1 Eng	"F" Line	½ qt low		NOT OPERATED	
#2 Eng	"F" Line	½ qt low		NOT OPERATED	

NOTE: APU Operating Only.

TABLE 6

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50°F
RUN NO. 11

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1950-2100	1950		1950	
APU Signal	1020-1180	300	Leaks 1180	300	
Power Steering	1020-1180	350	1100	1150	
#1 Flt Boost	1020-1180	300	1180	400	
#2 Flt Boost	1020-1180	1200		1500	
Utility	1020-1180	100	1180	200	
Brakes	600-850	800		850	

Reservoirs					
#1 Flt Boost	Gr Band	Gr Band		Gr Band	
#2 Flt Boost	Gr Band	Gr Band		Gr Band	
Utility	Gr Band	Gr Band		Low	

Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		1½ qt low	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	1 qt Overfull		2½ qts Overfull	
#1 Eng XMSN	Line	3/4 qt low		3/4 qt low	
#2 Eng XMSN	Line	Line		Line	
APU	DOT	½ qt low		DOT	
#1 Eng	"F" Line	3/4 qt low		"F" Line	
#2 Eng	"F" Line	3/4 qt low		"F" Line	

TABLE 7

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50°F
RUN NO. 12

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1950-2100	Sys Press		1950	
APU Signal	1020-1180	Sys Press		200	1180
Power Steering	1020-1180	1100		1100	
#1 Flt Boost	1020-1180	200	1180	350	1000
#2 Flt Boost	1020-1180	1120		1500	
Utility	1020-1180	Sys Press		600	1100
Brakes	600-850	1100		850	

Reservoirs					
#1 Flt Boost	Gr Band	Low	Serviced Gr Band	¼" above Gr Band	
#2 Flt Boost	Gr Band	Low	Serviced Gr Band	1/8" above Gr Band	
Utility	Gr Band	Sys Press		Gr	

Oil Levels					
Aft XMSN	Center of Glass	2 qts low	Added 2 qts	1 pt low	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	3/4 qt Overfull		2½ qts Overfull	
#1 Eng XMSN	Line	Line		Line	
#2 Eng XMSN	Line	½ qt low		½ qt Overfull	
APU	DOT	½ qt low		DOT	
#1 Eng	"F" Line	1 qt low		"F" Line	
#2 Eng	"F" Line	1 qt low		"F" Line	

* 45 minutes after aircraft shutdown.

TABLE 8

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -50°F
RUN NO. 13

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1950-2100	1850	2100	2000	
APU Signal	1020-1180	1180		1180	
Power Steering	1020-1180	1020		500	1180
#1 Flt Boost	1020-1180	1080		1200	
#2 Flt Boost	1020-1180	1180		1500	
Utility	1020-1180	1100		1180	
Brakes	600-850	850		825	

Reservoirs					
#1 Flt Boost	Gr Band	1/8" above Gr Band		¼" above Gr Band	
#2 Flt Boost	Gr Band	¼" above Gr Band		Gr	
Utility	Gr Band	Low	Serviced Gr Band	3/4" above Gr Band	

Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		Center of Glass	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	3/4 qt Overfull		3/4 qt Overfull	
#1 Eng XMSN	Line	3/4 qt low		½ qt low	
#2 Eng XMSN	Line	Line		½ qt Overfull	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	½ qt low		½ qt low	
#2 Eng	"F" Line	1 qt low		½ qt low	

* 30 minutes after aircraft shutdown

TABLE 9

SERVICING RECORD

YCH-47D USA S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE -50°F

RUN NO. 14

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1950-2100	1800	2100	2150	
APU Signal	1020-1180	1100		1200	
Power Steering	1020-1180	500	1180	750	1150
#1 Flt Boost	1020-1180	1200		1400	
#2 Flt Boost	1020-1180	1200		1500	
Utility	1020-1180	1100		1200	
Brakes	600-850	800		650	

Reservoirs					
#1 Flt Boost	Gr Band	3/16"above Gr Band		1/8"above Gr Band	
#2 Flt Boost	Gr Band	Gr		Gr	
Utility	Gr Band	1/8" above Gr Band		1" above Gr Band	

Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		Center of Glass	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	¼ qt Overfull		Line	
#1 Eng XMSN	Line	1 qt low		1¼ qts low	
#2 Eng XMSN	Line	½ qt low		½ qt low	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	1 qt low		"F" Line	
#2 Eng	"F" Line	½ qt low		"F" Line	

TABLE 10

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65°F
RUN NO. 15

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1890-2020	Removed for Maintenance	2000	3000 Pressurized	
APU Signal	960-1110	1100		2950 Pressurized	
Power Steering	960-1110	975		650	
#1 Flt Boost	960-1110	1150		200	
#2 Flt Boost	960-1110	100	1000	1000	
Utility	960-1110	1125		3000 Pressurized	
Brakes	600-850	850		700	

Reservoirs					
#1 Flt Boost	Gr Band	1/8" above Gr Band	Bled to Gr Band	1/8" above Gr Band	
#2 Flt Boost	Gr Band	2" above Gr Band	Bled to Gr Band	3/8" above Gr Band	
Utility	Gr Band	2" above Gr Band	Bled to Gr Band	Low	

Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		½ qt Overfull	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	Line		1½ qts Overfull	
#1 Eng XMSN	Line	1¼ qt low	Added 1 qt	¼ qt low	
#2 Eng XMSN	Line	½ qt low		½ qt Overfull	
APU	DOT	¼ qt low		DOT	
#1 Eng	"F" Line	1 qt low		1 qt low	
#2 Eng	"F" Line	1 qt low		1 qt low	

* 1½ hrs after aircraft shutdown

TABLE 11

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE -65°F
RUN NO. 16

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1890-2020	1900		2000	
APU Signal	960-1110	1100		1010	
Power Steering	960-1110	500	1100	600	1100
#1 Flt Boost	960-1110	200	990	200	1050
#2 Flt Boost	960-1110	950		990	
Utility	960-1110	1100		1100	
Brakes	600-850	650		475	850

Reservoirs					
#1 Flt Boost	Gr Band	Gr		Low	To Gr Band
#2 Flt Boost	Gr Band	¼" above Gr Band		Low	To Gr Band
Utility	Gr Band	Low		Low	To Gr Band

Oil Levels					
Aft XMSN	Center of Glass	½ qt Overfull		Center of Glass	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Com XMSN	Line	½ qt Overfull		1½ qts Overfull	
#1 Eng XMSN	Line	1 qt low		Line	
#2 Eng XMSN	Line	Line		½ qt Overfull	
APU	DOT	¼ qt low		DOT	
#1 Eng	"F" Line	1 qt low		½ qt low	
#2 Eng	"F" Line	1 qt low		½ qt low	

TABLE 12

SERVICING RECORD

YCH-47D USA S/N 76-3008
CLIMATIC LABORATORY TEMPERATURE -65°F
RUN NO. 17

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1890-2020	2600 Pressurized		2800 Pressurized	1900
APU Signal	960-1110	2200 Pressurized		850 Pressurized	1500
Power Steering	960-1110	1250		1150 Pressurized	1500
#1 Flt Boost	960-1110	200	1000	400	1500
#2 Flt Boost	960-1110	300	1000	1150	1500
Utility	960-1110	3050 Pressurized		1800 Pressurized	1490
Brakes	600-850	600		200	800

Reservoirs					
#1 Flt Boost	Gr Band	Gr		Gr	
#2 Flt Boost	Gr Band	Gr		Gr	
Utility	Gr Band	1" above Gr Band	Bled to Gr Band		

Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		½ qt low*	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass *	
Comb XMSN	Line	½ qt Overfull		1 3/4 qts Overfull*	
#1 Eng XMSN	Line	1 qt low		¼ qt low*	
#2 Eng XMSN	Line	Line		½ qt Overfull *	
APU	DOT	½ qt low		DOT	
#1 Eng	"F" Line	½ qt low		"F" Line	
#2 Eng	"F" Line	1 qt low		"F" Line	

(1 Instrumentation line failure - Reading low.

* 25 minutes after aircraft shutdown.

TABLE 13

SERVICING RECORD

YCH-47D USA S/N 76-8008
CLIMATIC LABORATORY TEMPERATURE +70°F
RUN NO. 18

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1525-1900	2050	1900	3300 Pressurized	
APU Signal	1290-1495	1400		3500 Pressurized	
Power Steering	1290-1495	1495		1500	
#1 Flt Boost	1290-1495	1350		1500	
#2 Flt Boost	1290-1495	1400		1500	
Utility	1290-1495	1450		3300 Pressurized	
Brakes	600-850	800		950	

Reservoirs					
#1 Flt Boost	Gr Band	1" above Gr Band	Bled to Gr Band	Gr	
#2 Flt Boost	Gr Band	2½" above Gr Band	Bled to Gr Band	Gr	
Utility	Gr Band	2" above Gr Band	Bled to Gr Band	Gr	

Oil Levels					
Aft XMSN	Center of Glass	1 qt Overfull	Drained 1 qt	2 qt low	Added 2 qts
Fwd XMSN	Center of Glass	Center of Glass		Not in glass Low	Added 3 qts
Comb XMSN	Line	¼ qt Overfull		1 qt Overfull	
#1 Eng XMSN	Line	1 qt low		½ qt low	
#2 Eng XMSN	Line	½ qt low		¼ qt Overfull	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	2 qts low	Added 2 qts	¼ qt Overfull	
#2 Eng	"F" Line	"F" Line		¼ qt Overfull	

* 30 minutes after aircraft shutdown

TABLE 14

SERVICING RECORD

YCH-47D USA S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE +70°F

RUN NO. 19

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run	Serviced To
APU Start	1525-1900	1900		3300 Pressurized	
APU Signal	1290-1495	1400		3500 Pressurized	
Power Steering	1290-1495	1450		1500	
#1 Flt Boost	1290-1495	1300		450	
#2 Flt Boost	1290-1495	1400		1500	
Utility	1290-1495	1425		3600 Pressurized	
Brakes	600-850	800		750	

Reservoirs					
#1 Flt Boost	Gr Band	Gr		Gr	
#2 Flt Boost	Gr Band	5/16"above Gr Band		Gr	
Utility	Gr Band	Gr		Gr	

Oil Levels					
Aft XMSN	Center of Glass	½ qt Overfull		1 qt low	
Fwd XMSN	Center of Glass	Center of Glass		Center of Glass	
Comb XMSN	Line	½ qt Overfull		Top of Glass Overfull	Drained 2 qts
#1 Eng XMSN	Line	2 qts low	Added 2 qts	Line	
#2 Eng XMSN	Line	½ qt low		3/4 qt Overfull	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	"F" Line		¼ qt Overfull	
#2 Eng	"F" Line	"F" Line		¼ qt Overfull	

TABLE 15

SERVICING RECORD

YCH-47D USA S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE +70°F

RUN NO. 20

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1525-1900	1900		3300 Pressurized	
APU Signal	1290-1495	1400		3550 Pressurized	
Power Steering	1290-1495	1400		1500	
#1 Flt Boost	1290-1495	1400		1475	
#2 Flt Boost	1290-1495	1400		1500	
Utility	1290-1495	1400		3750 Pressurized	
Brakes	600-850	750		750	

Reservoirs					
#1 Flt Boost	Gr Band	Gr		Gr	
#2 Flt Boost	Gr Band	1/16" above Gr Band		1/8" above Gr Band	
Utility	Gr Band	Gr		Gr	

Oil Levels					
Aft XMSN	Center of Glass	½ qt Overfull		1 qt low*	
Fwd XMSN	Center of Glass	¼ qt Overfull		Line *	
Comb XMSN	Line	½ qt low		Line *	
#1 Eng XMSN	Line	2½ qts low		1 qt low*	
#2 Eng XMSN	Line	1 qt low		½ qt low*	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	"F" Line		1½ qts Overfull	
#2 Eng	"F" Line	"F" Line		"F" Line	

* 25 minutes after aircraft shutdown.

TABLE 16

SERVICING RECORD

YCH-47D USA S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE +125°F

RUN NO. 21

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1500-1900	2000	1900	3450 Pressurized	
APU Signal	1425-1650	1500		3900 Pressurized	
Power Steering	1425-1650	1750	1600	3100 Pressurized	
#1 Flt Boost	1425-1650	1500		1550	
#2 Flt Boost	1425-1650	1600		1600	
Utility	1425-1650	1600		3700 Pressurized	
Brakes	600-850	850		850	

Reservoirs					
#1 Flt Boost	Gr Band	5/16"over Gr Band	Gr	Low	
#2 Flt Boost	Gr Band	5/16" over Gr Band	Gr	Gr	
Utility	Gr Band	Low	Gr	Low	

Oil Levels					
Aft XMSN	Center of Glass	2 qts Overfull	Drained 2 qts	1½ qt low*	
Fwd XMSN	Center of Glass	Top of Glass	Drained 3 qts	4 qts low*	
Comb XMSN	Line	Line		2½ qts Overfull	
#1 Eng XMSN	Line	1 qt low	Line	Line	
#2 Eng XMSN	Line	1¼ qts low	Added 1 qt	1 qt Overfull	
APU	DOT	DOT	DOT	DOT	
#1 Eng	"F" Line	"F" Line		"F" Line	
#2 Eng	"F" Line	"F" Line		"F" Line	

* 25 minutes after aircraft shutdown.

TABLE 17

SERVICING RECORD

YCH-47D USA S/N 76-8008

CLIMATIC LABORATORY TEMPERATURE +125°F

RUN NO. 22

Accumulators (PSI)	Limits	Pre-Run	Serviced To	Post-Run*	Serviced To
APU Start	1500-1900	2850	1900	1900	
APU Signal	1425-1650	3100	1600	1600	
Power Steering	1425-1650	1600		1550	
#1 Flt Boost	1425-1650	0[1]	1550	1500	
#2 Flt Boost	1425-1650	1600		1600	
Utility	1425-1650	3150	1600	1600	
Brakes	600-850	850		850	

Reservoirs					
#1 Flt Boost	Gr Band	Gr		Low	Gr Band
#2 Flt Boost	Gr Band	Gr		Low	Gr Band
Utility	Gr Band	Gr		Gr	

Oil Levels					
Aft XMSN	Center of Glass	Center of Glass		Center of Glass	
Fwd XMSN	Center of Glass	Center of Glass		1½ qts low	
Comb XMSN	Line	Line		2½ qt Overfull	
#1 Eng XMSN	Line	2 qts low	Added 1 qt	Line	
#2 Eng XMSN	Line	3/4 qt low		3/4 qt Overfull	
APU	DOT	DOT		DOT	
#1 Eng	"F" Line	"F" Line		½ qt Overfull	
#2 Eng	"F" Line	"F" Line		½ qt Overfull	

* 2½ hrs after aircraft shutdown.
[1] "O" ring failed.

APPENDIX G. EQUIPMENT PERFORMANCE REPORT SUMMARY

EPR No.	Date	Temp	Nomenclature	Description
1	9/16/80	Ambient	Seal-Fwd XMSN Input	During ground run, prior to test cell entry, the forward main transmission power input shaft seal was leaking oil (MIL-L-7808).
2	9/17/80	Ambient	Screen - Debris	During ground run, prior to test cell entry, both debris indicators (forward and aft main rotor transmissions) were leaking (MIL-L-7808).
3	9/17/80	Ambient	Actuator, Pivoting	During postflight inspection, maintenance personnel observed an accumulation of hydraulic fluid in the pilot valve protection boot area on the aft and forward rotor pivoting actuators. (MIL-H-83282)
4	9/17/80	Ambient	Actuator, Swiveling Aft	During postflight inspection maintenance personnel observed a hydraulic fluid leakage at a cylinder passage closeout plug. (MIL-H-83282)
5	9/06/80	Ambient	Filter, Aft Main XMSN	During initial test cell run, the main oil filter impending by-pass indicator had extended. The filter contained an excessive amount of exteraneous materials.
6	9/06/80	Ambient	Seal - Aft XMSN Input	During initial test cell run, the aft main rotor transmission power input shaft seal was seeping lubricating oil (MIL-L-23699).

EQUIPMENT PERFORMANCE REPORT SUMMARY - Cont

EPR No.	Date	Temp	Nomenclature	Description
7	9/12/80	+70°F	Seal, Hydraulic Pump	The aft transmission mounted utility and No. 2 flight control systems hydraulic pumps were seeping lubricating oil from their case drains during operation. (MIL-L-23699)
8	9/16/80	0°F	Valve, Hot Air	The number two engine anti-ice hot air valve would not operate on two separate test runs.
9	9/16/80	0°F	Seal, Fwd XMSN Input	The forward main rotor transmission power input shaft seal seeped a slight amount of MIL-L-23699 oil.
10	9/16/80	0°F	Seal, Utility Hyd. Pump	During the run, it was observed that there was a leakage of oil (MIL-L-23699) at the aft main rotor transmission mounted utility hydraulic pump case drain. Approximately 1 drop per 3-4 seconds.
11	9/23/80	0°F	Generator	Both aft main rotor transmission mounted generators sheared the overload protection devices after engine shutdown.
12	9/25/80	-25°F	Accumulator, APU Signal	The auxiliary power signal accumulator nitrogen precharge leaked below limits between test runs.
13	9/25/80	-25°F	Hand Pump, Utility Hydraulic	When the pump piston rod on the hand pump was actuated, hydraulic fluid (MIL-H-83282) seeped around the rod and pump end cap.

EQUIPMENT PERFORMANCE REPORT SUMMARY - Cont

EPR No.	Date	Temp	Nomenclature	Description
14	9/26/80	-25°F	Seal - Aft XMSN Input	During the 30 minute run after oil change, oil was leaking from the aft main rotor transmission power input seal at the approximate rate of one drop per 3-4 seconds.(MIL-L-7808)
15	9/30/80	-50°F	Hydraulic Module, System Return	As the auxiliary power unit was starting and "coming up" to speed, hydraulic fluid (MIL-H-83282) started to leak from the upper area of the utility hydraulic system return module.
16	9/30/80	-50°F	Hand Pump, Utility Hydraulic	During the ground pressurization, hydraulic fluid (MIL-H-83282) was seeping around the rod and pump end cap.
17	10/1/80	-50°F	Signal, Accumulator APU	During the pre-run inspection, the auxiliary power unit start signal accumulator nitrogen precharge was found depleted.
18	10/7/80	-50°F -65°F	Maintenance Panel	At lower test temperatures the hydraulic system selecting switches were intermittently inoperative.
19	10/2/80	-50°F -65°F	Starter Motors, Engine	At lower test temperatures the engine hydraulic starter motors seeped hydraulic fluid (MIL-H-83282).
20	10/7/80	-65°F	Accumulator, APU Start	Accumulator lost nitrogen precharge and would not reservice. After return to ambient temperature, accumulator functioned normally and was reinstalled.

EQUIPMENT PERFORMANCE REPORT SUMMARY - Cont

EPR No.	Date	Temp	Nomenclature	Description
21	10/8/80	-65°F	Ramp, Cargo	At -65°F the ramp and tongue assembly required repeated cycling prior to attaining normal operation. (MIL-H-83282 Hydraulic Fluid)
22	10/9/80	-65°F	Module assy, PTU	When No. 1 PTU was selected, it cavitated. The vibration loosened a pressure hydraulic line and caused a hydraulic leak (MIL-H-83282).
23	10/10/80	-65°F	Module assy, PTU	When the PTUs were selected (#1 and #2) they cavitated. No. 1 would only attain approximately 2000 psi, No. 2 remained inoperative due to cavitation. (MIL-H-83282 Hydraulic Fluid installed)
24	10/15/80	+70°F	Assy, Power Steering	The power steering assy. became inoperative.
25	10/16/80	-25°F -50°F -65°F +70°F	Valve, Thermal By-Pass	No. 2 engine transmission oil cooler thermal by-pass valve was sticking.
26	10/21/80	+125°F	Electronic Sequence Unit	Auxiliary power unit would not start prior to aircraft shutdown. The sequence unit had BITE indications.
27	10/21/80	+125°F	Seal - Forward Main Rotor Transmission Power Input Shaft	Lubricating oil (MIL-L-23699) was observed leaking from the forward main rotor transmission power input shaft seal during the post run inspection.
28	10/21/80	+125°F	Seal - Aft Main Rotor Transmission Power Input Shaft	Lubricating Oil (MIL-L-23699) was observed leaking from the aft main rotor transmission power input shaft seal during the post run inspection.

EQUIPMENT PERFORMANCE REPORT SUMMARY - Cont

EPR No.	Date	Temp	Nomenclature	Description
29	10/23/80	+125°F	Packing, "O" Ring	"O" Ring in #1 flight control boost accumulator nitrogen precharge service hardware was found ruptured on pre-run inspection.
30	10/23/80	+125°F	Control Box, AFCS	AFCS Inoperative @ +125°F.
31	10/28/80	All Temps	Transmission Oil Levels	Sightgage levels are unpredictable with time and temperature. Publications not accurate for levels. Drain and reservice capacities are inconsistent.
32	10/28/80	All Temps	Impending jam indicator extension on flight control actuators	Impending cylinder "jam" indicators intermittently and inconsistently extend on hydraulic PTU checks and during operation.
33	10/28/80	All Temps	Accumulators, Hydraulic	The hydraulic accumulators were inconsistent in retaining their nitrogen precharge. MIL-H-83282 hydraulic fluid was installed.
34	10/28/80	-25°F -50°F -65°F	Mike cord, flight engineer	The insulation/covering of the cord became very stiff and brittle at lower temperatures. Breakage caused loss of communications.
35	10/28/80	-25°F -50°F -65°F	Auxiliary Power Unit starting at lower temperatures	The APU seldom started on the first attempt at -25°F and -50°F. At -65°F, preheat was mandatory. MIL-H-83282 hydraulic fluid was utilized.
36	10/28/80	All Temps	Hand Pump, Utility Hydraulic	At lower test temperatures the hand pump became consistently less efficient. Preheat was a necessity at -25°F, -50°F and -65°F.

EQUIPMENT PERFORMANCE REPORT SUMMARY - Cont

EPR No.	Date	Temp	Nomenclature	Description
37	10/28/80	All Temps	Aft Main Rotor Transmission Servicing	Due to service neck location the transmission is difficult to service.
38	10/28/80	All Temps	Accumulators, Servicing	Nitrogen pre-charge pressure limits should be modified to meet greater temperature extremes.
39	10/28/80	All Temps	Gages, Accumulator Pressure	Gages are small and graduated in 500 psi increments. Accuracy is difficult to attain.

DISTRIBUTION

Deputy Chief of Staff for Logistics (DALO-SMM)	1
Deputy Chief of Staff for Operations (DAMO-RQ)	1
Deputy Chief of Staff for Personnel (DAPE-HRS)	1
Deputy Chief of Staff for Research Development and Acquisition (DAMA-PPM-T, DAMA-RA, DAMA-WSA)	3
Comptroller of the Army (DACA-EA)	1
US Army Materiel Development and Readiness Command (DRCDE-DH, DRCQA-E, DRCRE-I, DRCDE-RT)	4
US Army Training and Doctrine Command (ATTG-U, ATCD-T, ATCD-ET, ATCD-B)	4
US Army Aviation Research and Development Command (DRDAV-DI, DRDAV-EE, DRDAV-EG)	10
US Army Test and Evaluation Command (DRSTS-CT, DRSTS-AD)	2
US Army Troop Support and Aviation Materiel Readiness Command (DRSTS-Q)	1
US Army Logistics Evaluation Agency (DALO-LEI)	1
US Army Materiel Systems Analysis Agency (DRXSY-R, DRXSY-MP)	2
US Army Operational Test and Evaluation Agency (CSTE-POD)	1
US Army Armor Center (ATZK-CD-TE)	1
US Army Aviation Center (ATZQ-D-T, ATZQ-TSM-A, ATZQ-TSM-S, ATZQ-TSM-U)	3
US Army Combined Arms Center (ATZLCA-DM)	1
US Army Infantry Center (ATSH-TSM-BH)	1
US Army Safety Center (IGAR-TA, IGAR-Library)	2
US Army Research and Technology Laboratories (DAVDL-AS/DAVDL-POM)	1
US Army Research and Technology Laboratories/Applied Technology Laboratory (DAVDL-ATL-D, DAVDL-Library)	2

US Army Research and Technology Laboratories/Aeromechanics Laboratory (DAVDL-ATL-D)	1
US Army Research and Technology Laboratories/Propulsion Laboratory (DAVDL-PL-D)	1
US Army Research Technology Laboratories/Aeromechanics Laboratory (DAVDL-ATL-D)	1
US Army Materiel Development and Research Command (DALO-AV)	1
US Military Academy (MADN-F)	1
Defense Technical Information Center (DDR)	12

DATE

ILME

—8